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FRANKLIN K. LANE, SECRETARY

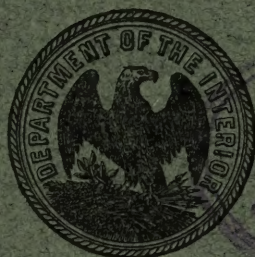
BUREAU OF MINES

VAN. H. MANNING, DIRECTOR

MINERS' NYSTAGMUS

BY

FREDERICK L. HOFFMAN



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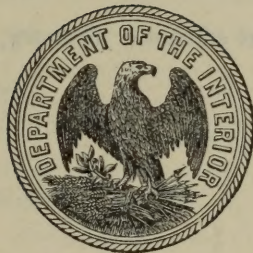
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PREFACE.

The prevalence of occupational diseases among miners in the United States is a matter of deep public concern, although it has received little systematic study as yet. The Bureau of Mines is directed by law to undertake investigations looking to the improvement of safety and health conditions in mines and, in cooperation with the Bureau of the Public Health Service, has done a limited amount of work in a few metal-mining districts, chiefly with regard to the prevalence of pulmonary tuberculosis and to the effects of rock dust, made by drilling and blasting, as an exciting cause of diseases of the lungs.

In the absence of broad and detailed studies it is impossible to say whether diseases common among European miners are prevalent in the same relative proportions among miners in the United States. It is to be presumed, however, that those diseases that are induced by specific causes, such as the breathing of fine sharp particles of siliceous rock or work under conditions that tend to strain excessively any organ of the body, will be found to occur in the United States in proportion as these causes are effective. In other words, it is to be expected that, owing to the differences in natural conditions and in mining methods, certain diseases will be found to be more prevalent in one country or in one district than in another.

Miners' nystagmus seems to be widespread in Europe and to be decidedly common in some districts there. As it may prevent a miner from working at his regular task and may even cause prolonged total disability, it is recognized in both England and Germany as properly entitling the sufferer to compensation under the provisions of employers' liability or workmen's insurance laws.

Workmen's compensation laws have been enacted in more than thirty of the States in the United States, and there is widespread interest in the subject of occupational diseases. The Bureau of Mines in its investigations of safety and health conditions in mines is giving attention to the ailments to which miners are particularly subject as a result of their daily work. The following paper on miners' nystagmus has been prepared by Mr. Hoffman, who has given years of study to the morbidity and accident rates of different occupations and is widely known through his writings on occupational accidents and diseases.

As there has been no thorough investigation of miners' nystagmus in the United States, Mr. Hoffman has reviewed the results of investigations in Europe and has drawn some tentative conclusions as to the possible frequency of the disease in this country. Possibly some

American physicians and mining engineers will doubt that many American coal miners are afflicted with nystagmus, and will advance as reason for their opinion the use of undercutting machines in the United States and the lessened amount of undercutting now done with the pick. The use of open-flame lamps in the many nongaseous mines and the increasing use of electric lamps in gaseous mines and the better illumination obtainable by them than by the safety lamps generally used in Europe may be, in the opinion of some engineers, additional reasons for believing that there is less eye strain, the cause of nystagmus, among American than among European coal miners.

Whatever may be the prevalence of nystagmus in the United States, its seriousness as a disease and the need of national and State agencies cooperating in endeavors to obtain exact information regarding it are deemed sufficient reasons for the publication of Mr. Hoffman's interesting and suggestive paper.

VAN. H. MANNING.

MINERS' NYSTAGMUS.

By FREDERICK L. HOFFMAN.

INTRODUCTION.

Miners' nystagmus is the result of a peculiar form of eyestrain, which often results in impairment of vision and a consequent diminution of the wage-earning capacity of the workman.

Historically it has been pointed out by Shufflebotham^a that "This disease was first recognized by Gillett, of Sheffield, about 1854, although no case was mentioned in medical literature until 1861, when the symptoms were described by De Conde, a Belgian physician. Cases were reported by Pepp Müller as early as 1860, by Von Graefe in 1873, and by Bell Taylor, of Nottingham, and by Nieden in 1874. In this country (England) we are indebted to a very large extent to the observations and writings of the late Simeon Snell and for his pioneer work on this many-sided disease; in France Dransart occupies a similar position." In the treatise on "The Effects of Arts, Trades, and Professions," by C. Turner Thackrah, published in London in 1832, it is stated that—

The complexion of the colliers, even after the removal of the dirt, is generally sallow and unhealthy. Their eyes, from the swelling of the lids, appear small, are affected with chronic inflammation and intolerant of full light. * * * Sickness and vomiting sometimes affect persons at their commencing the employ; and many, after a few years' trial, are obliged, by the injury which their health has sustained, and especially by the weakness of their eyes, to leave the mine.

According to Greer,^b an authority on industrial diseases and accidents, miners' nystagmus occurs in 5 per cent of all miners, but it is quite probable that the reference is to European coal miners rather than to men employed in all branches of the mineral industry. According to the same authority,^c miners' nystagmus "is associated with a twitching of the eyelids and with considerable diminution of the range of movement of the eyes, and is particularly liable to occur in patients whose vision is subnormal owing to errors of refraction, especially astigmatism. It causes much inconvenience to those suffering from it and prevents them from following their usual occupation as, owing to the movements of the eyes, everything at which they look appears to be in a state of perpetual motion, and in conse-

^a Shufflebotham, Frank, *Miners' nystagmus*: Brit. Med. Jour., Mar. 21, 1914, p. 648.

^b Greer, W. J., *Industrial diseases and accidents*, London, 1909, p. 304.

^c Greer, W. J., *Loc. cit.*

quence their visual acuity is more or less reduced. When the movements cease the vision becomes as good as it was previously."

Barnett,^a with reference to the British workmen's compensation act of 1906, states that nystagmus "is a condition often found in miners owing to excessive strain of the eye. The cause of the affection is the constrained position of the eyes, producing chronic weariness. It is usually present in those miners engaged in 'kirving' or bottom-holing a seam of coal; in doing this they have to lie in a very strained position, striking the coal with a horizontal swing of the pick, and having to keep their eyes fixed on one spot, using the elevator muscles constantly."

The symptoms of the affliction are stated by Barnett to be as follows:

There are usually objects dancing before the eye. There is oscillation of the eyeball, headache is often present, and giddiness sometimes causes the miner to stumble. The movements of the eyeball are rotary and to and fro, rarely vertical; the rapidity of the motion may be great. Tremors of the muscles of the head and face are often associated with the trouble.

SOURCES OF INFORMATION.

The literature on nystagmus is considerable, but is limited chiefly to contributions to medical and mining periodicals. A complete treatise on the subject of miners' nystagmus was published in 1894 at Wiesbaden, by Nieden.^b There are numerous descriptive accounts of individual cases of miners' nystagmus, most of which confirm the view that the immediately responsible cause for the disease is the defective illumination under which underground mining is frequently carried on. There are other forms of nystagmus, both congenital and hereditary, and some cases of the disease have been reported for men employed in other occupations than mining, including a case of nystagmus in a compositor, reported by Snell^c in 1890. As pointed out by Thompson,^d in his recent work on occupational diseases—

Nystagmus as an occupational symptom is not alone confined to miners, and may develop in those who are compelled to give close visual attention to constantly moving objects. For example, Dr. Collie, of the British factory inspection service, found that 28 per cent of 516 female sewing-machine operatives had slight grades of nystagmus from fatigue of the eye muscles in following the work through the machine. Exceptional cases have occurred among compositors who kept their copy above the eyes and threw the head backward to glance at it.

According to the same authority,^e the symptom of rapid oscillation of the eyeballs, typical of miners' nystagmus, "is due to picking at

^a Barnett, H. N., *Accidental injuries to workmen*, London, 1909, p. 133.

^b Nieden, A., *Der Nystagmus der Bergleute*, 1894, 140 pp.

^c Snell, Simeon, *Eye diseases and eye accidents in relation to industrial occupations: In "Dangerous Trades,"* by Thomas Oliver, London, 1902, chap. 58, pp. 761-765.

^d Thompson, W. G., *The occupational diseases; their causation, symptoms, and prevention*, 1914, p. 570.

^e Thompson, W. G., *Op. cit.*, pp. 569-570.

overhead coal, which requires strain of the eye muscles, the eyes being constantly directed both upward and to one side. It is therefore limited to those who handle the pick exclusively. The symptom usually subsides in time after the form of work has been changed. It is at present a rare phenomenon, owing to two causes—first, the increasing introduction of machine methods and, secondly, the operation of the gross-weight law, whereby miners are paid for the gross tonnage of the coal mined, not on the basis of the size of the nuggets. When the latter system prevailed the miners sought to increase their earnings by carefully picking out large fragments of coal, which involved the ocular strain.”

Thompson^a quotes Browne and Mackenzie to the effect that—

The contributing factors in producing this symptom are: Inadequate light, errors of refraction, straining of the extrinsic eye muscles, and a neurotic temperament. Ninety per cent of their patients had errors of refraction. The symptom is often attended by severe pains in the head and eyes and by quivering of the eyelids. The miners find some relief from the affection by walking with the eyes directed downward. No special treatment, except rest, is of any avail, and after a prolonged period spontaneous recovery may take place, which may be partial if not always complete.

The following suggestive description of nystagmus is by Louis:^b

Probably the most unhealthful part of the coal miner's work consists in “kirving” or undercutting the coal, in doing which the miner has to lie on his side on the floor of the coal seam, swinging his pick with a peculiar sideways stroke over his head, till he has cut out a narrow groove some 3 feet deep below the overhanging mass of coal. Work in this constrained position is necessarily harmful to some extent. Its effect has been most noticed as affecting the nervous system, and especially the nerves of the eyes, the disease known as miner's nystagmus having been often ascribed to it. Cases of miner's nystagmus occur, however, also among miners who do not have to kirve, and it may well be due in great part to the poor light obtainable in so many cases underground, especially when safety lamps are used, and the consequent strain on the eyes. At any rate this seems to be the opinion of several who have suffered from this complaint.

OCCUPATIONAL EYESTRAIN.

In the same work, in connection with a discussion of eye diseases and eye accidents in relation to industrial occupations, Snell,^c a recognized authority on ophthalmology, contributes an extended discussion on nystagmus, not only among miners, but also among persons employed in other occupations underground. The findings and conclusions of Snell have not been accepted in their entirety by other authorities on the subject of nystagmus, but they are given in full so as to provide the necessary basis for comparison with divergent views subsequently to be quoted.

Coal miners, as a result of their employment, are especially prone to a peculiar affection of the eyes called “nystagmus” (miners' nystagmus), which is characterized by

^a Thompson, W. G., *Op. cit.*, p. 570.

^b Louis, Henry, *Mining: Thomas Oliver's "Dangerous Trades,"* London, 1902, chap. 37, p. 534.

^c Snell, Simeon, *Eye diseases and eye accidents in relation to industrial occupations: In "Dangerous Trades,"* by Thomas Oliver, London, 1902, chap. 58, pp. 760-772.

oscillations of the eyeball. The sufferer, too, complains of objects dancing before his eyes. In this disease objects appear to move either in a circle or an ellipse. Head-ache is often present, and especially giddiness, which sometimes causes the miner so to stumble about that he is compelled to leave his work in the mine. The movements of the eyeball are chiefly rotatory; to-and-fro oscillations are sometimes superadded. These are rarely vertical, but the rotatory are seldom, if ever, absent. The rapidity of the ocular motions varies greatly; from 60 to 150 motions may be counted in a minute. I have observed them as frequent as 350. Both eyes are affected, but the rapidity of movements may vary in the two eyes. The more rapid the oscillations the less extended is the excursion of the globes. The oscillations are arrested by turning the gaze downward below the horizontal line, and miners often learn to rest their eyes in this way. Looking upward, and especially obliquely to one side or the other, rapid movements of the head, lowering of the head, and suddenly raising it are means of increasing the rate of movements of the eyeballs, or, in other cases, of rendering them evident. Placing the patient in the position he would assume at his work is another method. Tremors of the head (noticeable to the hand placed on the head), of the eyelids, and of the muscles of the face or neck are often associated with nystagmus, and so is torticollis or "wry neck" in some cases. Night blindness has been alleged to be present, but there is some reason to dispute this. The nystagmus alone is a sufficient cause for any difficulty in seeing in a failing light. Errors of refraction, myopia, hypermetropia, and astigmatism are often present, but bear no causal relation to nystagmus; visual acuity is generally unaffected. Color perception is good, and, so far as the movements of the eyeballs permit of testing, the field of vision is normal. The onset of the disorder is often brought about by some attack of illness. It is generally met with in men who have worked in the mine for some years. Ninety per cent of cases occur in persons from 25 to 45 years of age.^a

Nystagmus is found chiefly in miners who work at the coal face in a more or less constrained position of the body and the eyes. The methods of mining in England differ somewhat from those in this country, especially in details that have an important bearing on the occurrence of nystagmus, and therefore it seems appropriate to include a brief abstract from the article of Snell regarding conditions under which nystagmus in English coal mines is most likely to occur. The abstract follows:^b

It is desirable to get coal in as large pieces as possible, and to do this they undercut or "hole" the seam. A man sits with his legs crooked up, lying almost on his side, and strikes the coal with a horizontal swing of his pick at the bottom of the coal seam. He will cut away the coal to a height of 18 inches to 2 feet, and then as he gets deeper in he will draw his body under the coal, lying on one side or the other. The process is called "holing," and sometimes the undermining may be continued from 2 to 3 feet to as much as 7 or 8 feet; the distance varies considerably. As he proceeds with his work the miner applies timber supports to keep the coal from falling. This just described is called "bottom holing," but the seam may be attacked in the middle (middle holing) or at the top (top holing). A miner engaged at this work will direct his gaze to different parts as it becomes necessary for him to strike, for the eyes will follow the pick point, but the tendency will be for the gaze to be directed upward (using the ocular elevators) more or less obliquely. He will lie sometimes on one side and sometimes on the other. His legs will be crooked up, his head thrown back and flexed more or less on the shoulder beneath. * * * Ninety-eight per cent of all cases of nystagmus coming under my notice have been in men occupied at the coal face and more or less engaged at this kind of work.

^a Snell, Simeon, Eye diseases and eye accidents in relation to industrial occupations, in "Dangerous Trades," by Thomas Oliver, London, 1902, chap. 58, pp. 761-762.

^b Snell, Simeon, *Op. cit.*, pp. 762-763.

NYSTAGMUS A DISEASE OF COAL MINERS.

Regarding other underground occupations liable to nystagmus, the disease appears to be rare among them. Thus, for illustration, overseers whose work requires the inspection of underground conditions, both as regards freedom from gas and the security of the roof of the room or chamber in which the work is being done, suffer occasionally from nystagmus, according to Snell, probably because of the fact that their particular duties necessitate "the same upward and oblique direction of the gaze." He points out, however, in this connection that frequently the men employed as overseers have previously worked as coal miners, and he therefore concludes that, as a rule, all cases of nystagmus occur in those who are either working or have worked as coal miners, or who work in such positions as to require an upward direction of the eye for more or less prolonged periods. He also concludes that the causation of the affection "must be sought in this constrained position of the eyes by which chronic weariness is induced in the elevator muscles of the eyes. Like effects are found in other muscles of the miner, producing wry neck, tremors of the head, and quivering of the eyelids. It is thus similar to other occupational neuroses and in the same category as those found in writers, compositors, telegraphers, and many others."

BEARING OF INSUFFICIENT ILLUMINATION.

As regards the important question of insufficient or imperfect lighting, the opinion is expressed by Snell ^a that nystagmus occurs among miners working with all kinds of lighting, and that he has met with it among those working with safety lamps, candles, large open lamps, as well as when the artificial light was really good. He concludes, however, that there are reasons "for believing that the strain is greater the worse the light, and that nystagmus is met with in greater frequency under such conditions." He quotes Nieden to the effect that 5 per cent of coal miners suffer from nystagmus, and he adds that his own observations support this view, but that in some places the percentage is higher. For illustration, among men working at a colliery with candles only, he found that 6 out of a total of 140 were absent from work on account of nystagmus, and that this represented only a part of those who, on examination, would have shown to have been actually affected with the disorder. Snell ^b quotes Romi  , a Belgian authority, to the effect that the percentage of nystagmus cases was as high as 20, but he adds that this probably includes the less marked cases.

^a Snell, Simeon, *Op. cit.*, p. 764.

^b Snell, Simeon, *Op. cit.*, pp. 760-762.

PROGNOSIS, TREATMENT, AND CURE OF NYSTAGMUS.

The prognosis in nystagmus, according to Snell, is usually good, even for old-standing cases, if the directions as to a change of work are followed, and in such cases the nystagmus will usually disappear. As to treatment, particularly with reference to a change of occupation, Snell^a points out that—

In some cases it will suffice if the patient ceases from coal getting, without altogether stopping work in the mine, but generally it is advisable, especially if the nystagmus be of a high degree and of some standing, to recommend cessation altogether from work underground. After relief has been effected, return to the mine is practicable, provided the head can be kept straight and the upward turn of the eyes avoided. Resumption of the old kind of work is followed, sooner or later, by a recurrence of the symptoms. Medicinal treatment is also of service.

Finally, as regards the occurrence of nystagmus in other occupations than mining, Snell^b states that he observed the affliction, among others, in "compositors, metal roller, plate layer, plank cutter, saw maker, sanitary tube maker, fitter, iron founder, cage worker in a mine, glass manufacturer, youth in confectionery warehouse, and a man engaged in hanging up harness, and in another employed at the screens at the surface of a coal mine."

All of these instances, Snell points out, occurred under circumstances comparable to mine work, particularly as regards the strain upon the elevator muscles of the eyeball, on which, in his opinion, the degree of illumination had no effect. This conclusion, however, is not generally accepted.

FREQUENCY OF OCCURRENCE.

The first practical question is the probable number of miners affected with nystagmus. There are, unfortunately, no conclusive data on this subject, and the results of the only investigation that appears to have been made in this country—that is, in the State of Illinois—proved negative. According to the census of 1910 the number of men employed in coal mines in the United States was 613,519. If the proportion of miners affected with nystagmus were 5 per cent, the number of such cases in this country would be 30,676. In view of the paucity of references to nystagmus in American medical literature, it is extremely doubtful whether this proportion holds good for this country, as, seemingly, there have been few cases in American mines, although no thoroughly qualified ophthalmic study has yet been made.

One of the most important contributions including American data was published some years ago by Nieden,^c of Bochum, the center of the coal-mining district of Rhenish Prussia. The study includes an examination of 7,500 miners. The pure rotatory form of nystagmus

^a Snell, Simeon, Eye diseases and eye accidents in relation to industrial compensation, in "Dangerous Trades," by Thomas Oliver, London, 1902, pp. 760-762.

^b Snell, Simeon, Loc. cit.

^c Nieden, A., Der Nystagmus der Bergleute, Wiesbaden, 1894, 140 pp.

was found to occur in 72 per cent of the cases, the oscillating form in 12.5 per cent, and the mixed form in 15.5 per cent. Nieden questions the accuracy of Romiée's conclusion regarding a proportion of 20 per cent of nystagmus cases; and his own investigations made for the purpose of determining the facts, at least for the mining districts of Rhenish Prussia, were made with characteristic German thoroughness, and the existence of nystagmus in an acquired form was accurately determined in 299 cases out of a total of 7,416 miners, or 4.03 per cent.

On examination of 2,003 miners returning from work he found a proportion of 3.2 per cent suffering from nystagmus, whereas 1,913 men on commencing work were found to suffer in the proportion of 2.9 per cent. This result applies to a particular section and is, therefore, not strictly comparable with the total for the entire group examined, for which the combined percentage of nystagmus cases was 4.03. The difference as regards the occurrence of nystagmus on entry or exit can not be considered of great importance, but a more extended inquiry might disclose a more pronounced deviation from the normal.

Nieden adds an extremely interesting comparison of the frequency of nystagmus, based on his own examinations of miners and the results of his own private practice. Out of 3,017 miners requiring attention on account of eye troubles during a period of seven years, there were 172 cases of nystagmus, or 5.6 per cent. Against this proportion Nieden quotes 29,640 private cases of eye afflictions, out of which only 0.54 per cent were cases of nystagmus. In his opinion, therefore, the high proportion of 20 per cent as given by Romiée was not sustained by the experience in the Bochum mining district.

It is quite possible, however, that wide variations would be found to exist in different coal fields, for it is safe to maintain that the disease in the coal areas of the United States is relatively rare; in fact, Nieden points out that, according to his own investigations, most of the cases of nystagmus occurred among miners working in narrow seams, and that miners in some sections, where mining conditions were better, were practically free from the disease. Thus, for illustration, he determined that in the coal seams north of Bochum 7 per cent of the miners were afflicted with nystagmus, whereas in the coal seams south of Bochum only 0.25 per cent were affected. Upon further inquiry, however, he ascertained that in the northern coal seams the use of safety lamps was practically universal, whereas in the southern coal seams most of the men worked with open lamps and therefore under better conditions as regards illumination. He determined, by means of strictly scientific methods, that a miner using a Davy safety lamp during an eight-hour period worked under about one-third the amount of illumination normally provided by an open lamp.

On examining the records, he found that of 117 miners treated by him on account of nystagmus, 107, or 91.4 per cent, used safety lamps, whereas in two mines using open lamps and employing 772 men, only 0.35 per cent was found to be afflicted with nystagmus. He points out, however, that it was not only the insufficient illumination derived from the Davy lamp, but also its imperfect construction as regards the largest amount of possible effective illumination that was to be held responsible as a causative factor in nystagmus.

The relative frequency of this disease is referred to by Shufflebotham as follows:^a

Dr. Court has stated, as a result of the examination of several thousands of workmen, that 35 per cent of coal getters are subject to this disease to some extent. Snell estimated that 5 per cent of all colliery workers were affected, but he did not discriminate between different kinds of work in the coal pit. Nieden, who examined nearly 30,000 coal miners, agrees with Snell that the frequency of nystagmus in underground workers is somewhere about 5 per cent. In the north of France Dransart and Famechon have given 10 per cent as the number affected. Romiée and Thiebert, of Liege, during 1908 and 1910 examined 5,000 workmen in 27 collieries. More than three-fifths were coal getters, and on the average 21 per cent were affected with symptoms of nystagmus; in collieries lighted by lamps burning heavy oils 37 per cent of the coal getters were affected. Romiée had made a similar inquiry in the same district in the years 1877-78, and the result of his later inquiry was to show a marked diminution in the number of cases as well as in the severity of the symptoms. Stassen, who in 1909 examined 3,385 colliers descending into the pit, and also on their return to the surface, found that 15 per cent of the workers were affected before commencing their work and 22 per cent at the end of the shift.

Roger, of Hondeng-Geognies, as a result of examining over 7,000 workmen, came to the conclusion that 17.5 per cent were suffering from nystagmus. Liebert, the chief inspector of mines to the Belgian Government, found different percentages of miners affected in different districts. In one series of examinations which he conducted with the help of Romiée and Thiebert he found that of 305 workmen examined in one pit 73 were affected with miners' nystagmus, giving a percentage of 23.9, and he refers to a memoir dealing with 3,685 workmen, among whom 704 showed symptoms of this disease, or a percentage of 19.1.

OTHER EYE DISEASES OF MINERS.

Aside, however, from the question of imperfect or insufficient illumination, Nieden^b found that in a preponderating number of cases the miners suffered from other eye afflictions, including trachoma, dimness of the cornea, chronic iritis, irido-choroiditis, atrophy of the optic nerve, etc., all of which, of course, would predispose to nystagmus under the special conditions of underground work at the face of the seam. The only specific suggestion that he makes as regards prevention is the necessity for better artificial illumination by means of safety lamps, and he refers to electric mine lamps used in the Newcastle (England) district, but these, of course, do not indicate the presence of dangerous gases.

^a Shufflebotham, Frank, *The hygienic aspect of the coal-mining industry in the United Kingdom*: Brit. Med. Jour., Mar. 21, 1914, p. 648.

^b Nieden, A., *Der Nystagmus der Bergleute*, Wiesbaden, 1894.

CONCLUSIONS OF LINDEMANN.

On the occasion of the Fifteenth International Congress on Hygiene and Demography, Lindemann,^a chief medical director of the Bochum Miners' Union, contributed an address on the occupational diseases of miners, in which the subject of nystagmus is briefly referred to. He admits that the disease is of comparatively common occurrence, and points out that general debility, anemia, and alcoholism may be contributory causes, aside from the high underground temperature and excessive muscular strain. He dissents from certain conclusions by Snell with regard to the inability of miners suffering from nystagmus to recognize in time the blue cap on the safety lamp, indicating dangerous gaseous conditions. According to his own investigations, miners suffering from nystagmus were, without exception, able to determine the presence of fire damp to the extent of 2 to 3 per cent with absolute certainty. He refers to the rule of the Allgemeiner Knappschafts Verein zu Bochum (Bochum Miners' Union) (which is the compulsory miners' insurance association) that miners afflicted with nystagmus are not permitted to work underground, and that nystagmus itself entitles to compensation, both as regards money payments for support and medical treatment, as well as an invalidity pension. He states that an additional rule is to the effect that miners whose normal vision has been reduced 50 per cent are not permitted to work underground. As regards treatment, he states that good results follow only when underground work is discontinued at an early stage of the disease.

In this connection a brief reference may be made to the recently published experience of the Bochum Miners' Union^b for the year 1912, as regards the frequency of nystagmus as a cause of invalidity. Out of 3,605 cases of invalidity, 649, or 18 per cent, were on account of nystagmus, and 75, or 2.1 per cent, on account of other diseases of the eye. As the membership of the fund for the year 1912 was 376,000, this would be equivalent to an invalidity rate on account of nystagmus of 1.73 per 1,000 employed.

The foregoing preliminary observations emphasize the practical importance of nystagmus wherever the disease prevails to a considerable extent. A strictly localized investigation should limit itself to a mining district in which the miners use safety lamps and undercut the coal with the pick.

^a Lindemann, Wilhelm, Über die Unglücksfälle und Berufskrankheiten der Minen und Tunnelarbeiter: Trans. Fifteenth Int. Cong. on Hygiene and Demography, vol. 3, 1913, pp. 673-690.

^b Verwaltungs-Berichte, Allgemeiner Knappschafts Verein zu Bochum, 1912, Bochum, Germany, 1913.

NYSTAGMUS AS A MINING PROBLEM.

Nystagmus is not referred to in the "Report on Mining Methods and Appliances Used in the Anthracite Coal Fields,"^a published by the Second Geological Survey of Pennsylvania in 1883. There is also no reference to the disease in the section on "Hygiene of Occupation"^b published in Buck's "Hygiene and Public Health," in 1879. The importance of the disease has come to the front as a practical question in mine management only since the adoption of the workmen's compensation act in England of 1906 and the inclusion of nystagmus in the schedule of occupational diseases for which compensation is required to be paid. In a treatise by Cockin^c it is said under "Nystagmus" that—

This is a disease which affects the nerves of the eyes; it is more prevalent among those who work by the light of safety lamps than among those who use naked lights. The cause of nystagmus is thought to be either the constant dazzling of the eyes by the bright concentrated light of safety lamps or the strain put upon the muscles of the eyes by work, such as holing. The symptoms of this disease are a twitching of the eyes and impaired sight.

This inadequate reference emphasizes the lack of appreciation of the importance of an affliction that may be much more common in this country than is generally supposed. As there is unquestionably close interrelation between nystagmus and the use of safety lamps, it is regrettable that the extended consideration given to this part of mine equipment in most of the textbooks on coal mining should be practically without useful references to the prevention of a disease which, wherever it occurs, is, without question, a most serious affliction of the men employed, and an important factor of cost in mine management wherever workmen's compensation laws require compensation to be paid for cases of nystagmus directly attributable to the employment.

MEDICAL CONSIDERATIONS.

It has therefore seemed advisable to enlarge upon the medical aspects of a problem that is practically certain, in the near future, to attract attention in the United States, if only along negative lines, to prove beyond a doubt that the affliction is not as common in this country as it is known to be abroad. As pointed out in an editorial in the Journal of the American Medical Association:^d

The careful study of occupational diseases is one of the features of the modern conservation movement coming with the recognition of the economic advantage which attaches to the preservation of health in the industrial population. As an instance of the financial aspects of some of these matters we may cite a recent estimate of the cost of the 1,618 cases of miners' nystagmus in the United Kingdom in 1910. The

^a By H. M. Chance; 573 pp.

^b Buck, A. H., A treatise on hygiene and public health; Hygiene of occupation, by R. S. Tracy, vol. 2, 1879, pp. 1-96.

^c Cockin, T. H., Practical coal mining, 1909, p. 405.

^d Vol. 59, Aug. 17, 1912, p. 547.

compensation of these individuals is calculated at over \$155,000, a figure which does not take into account the poor earning capacity of the men in the incipient stages of the disease and other profits lost by the employers. Aside from its purely humanitarian or scientific aspects, therefore, successful investigation of such an industrial disease promises to pay a rich return. This statement needs to be brought home to American captains of industry who have as yet made only a beginning in a direction almost certain to lead to a profitable outcome from every point of view.

Among miners nystagmus is an occupational neurosis characterized by an involuntary oscillation of the eye-bulbs on fixation. It seems to be confined to the workers in coal mines and prevents the miner from accurately fixing anything toward which his vision is directed. Such a disturbance of vision evidently must seriously impair the working capacity of an individual who needs to strike accurately with his pick or to match timbers well in collieries.

There are two prominent views with regard to the etiology of the disease. One of these attributes the nystagmus to the strain of accommodation in the presence of deficient light; the other view associates the disease with the positions taken by the colliers, and assumes that there is a local myopathy affecting the elevator muscles of the eye. The cause and prevention of miners' nystagmus has been investigated lately by Dr. T. L. Llewellyn. It is a striking fact that the disease does not occur in the metalliferous mines where safety lamps are not required. In mines where candles can be used or where electric lamps are in operation nystagmus is not found. Now the safety lamp gives much less light, quickly becomes dirty, throws shadows, and must be placed out of the reach of the picks. We are apt to overlook the amount of our light which is due to the diffuse reflection from the walls of the room in which we happen to be. In the coal mine practically all of the light is absorbed; hence the need of satisfactory sources of illumination.

The disease is shown to attack the men who use their eyes in a much larger proportion than the other men. A large proportion of them suffer from errors of refraction. All have weakness of accommodation. Llewellyn regards nystagmus as a disease of great complexity and one in which many factors are at work. The chief of these is strain caused by deficient light. He believes that, as the result of working for long periods in the comparative darkness of the pit, the cells of the retina probably lose their power of producing sufficient pigment for exact vision. This failure occurs sooner in fair blue-eyed people and in those who are subject to a greater eye-strain, owing to errors of refraction. The more frequent occurrence of nystagmus in winter, the loss of visual acuity, the dread of light, are all points in favor of this theory. Another is the oblique position in which the head is held in many cases, whereby an attempt is presumably made by the patient to bring a fresh part of the retina into action. Darkness itself, Llewellyn suggests, is not enough to set up nystagmus.

Here are the preventive measures proposed: No man with refractive errors should be allowed to work underground and no man should be employed without medical examination. Above all, however, comes the improvement in the lighting power of the miner's lamp. If possible a lamp giving a diffused light should be introduced. Improved ventilation also means a better light. The study of the introduction of electric lamps promises to be of great interest in this connection.

CONTROVERSIAL ASPECTS.

Much to the same effect is an extended editorial discussion on the subject in the *British Medical Journal*^a of April 13, 1912. The editorial draws attention to the correspondence between Markham, a coal owner, and the Secretary of State for the Home Department, arising

^a Pp. 853-854.

out of a letter to Markham from Dr. J. Court, of Stavely, Derbyshire, whose views are based on 40-years' experience in coal-mining. Court urged that an inquiry should be undertaken into the eyesight of all men and boys working in collieries and other mines in Great Britain, where both naked lights and safety lamps are used, in order to ascertain (1) the cause or causes of miner's nystagmus; (2) the duration and best means of cure; (3) whether there is a constitutional liability; (4) whether one attack predisposes to another; (5) whether mild cases of nystagmus incapacitate a miner for work underground; and if so, to what extent; and (6) whether miner's nystagmus causes the sufferer to be a danger to himself and other miners at work with him. An abstract from the editorial follows:

There are two views as to the cause of miners' nystagmus. The one attributes it to eyestrain due to working in a badly lighted space with black light-absorbing surfaces; the other to strain of the extrinsic muscles of the eye, especially of the elevator muscles, due to the position of the miner when at work at the coal face, or when examining the roof of the workings to detect gas or threatening falls. The view hitherto most generally accepted is the second, a theory which brings the condition into the same category as writer's cramp and other occupational neuroses. This theory was strongly held by the late Mr. Simeon Snell, who supported it by many cogent arguments drawn from his long experience in treating eye affections among coal miners. He had the support of Nieden, Dransard, and some other continental authorities, but the theory has always been open to the objection that the disorder is seldom met with except among men working in coal mines; those engaged in other mines, it is said, are seldom or never affected in this way. In a paper on the causes and prevention of miner's nystagmus, communicated recently to the Royal Society by Dr. J. S. Haldane, Dr. T. L. Llewellyn, of Bargoed, Glamorganshire, advanced the theory that the nystagmus was due to a condition of imperfect centripetal impulses (imperfect fixation, disturbance of equilibrium, etc.), the intimate connection between the centers governing the associated movements of the eyes being lost and incoordinate movements ensuing. Dr. Haldane has informed the Home Secretary that Dr. Llewellyn's researches in a number of coal fields and also among metalliferous miners confirm Dr. Court's conclusion as to the connection between nystagmus and the very poor light given by ordinary safety lamps. Dr. Llewellyn found errors of refraction (hypermetropia, or astigmatism) present in 93 per cent of 280 cases examined, and concludes that the personal proclivity to the disorder which is undoubtedly an important factor, since only a small percentage of coal miners are affected, may be due to these defects, but he admitted that accident, shock, and ill health are also predisposing factors. He found that the disorder certainly diminished with improved illumination, being almost unknown in naked-light districts, and the principal preventive measures he indicated were improvement of illumination (which Dr. Court also advocates, suggesting the use of electric lamps), employment of coal-cutting machines in thin seams, and the elimination of unfit workers by medical examination.

NYSTAGMUS A MINE-SAFETY PROBLEM.

The practical importance of these observations is obvious. The evidence upon several important controversial points, however, could hardly be considered sufficient. Snell,^a in his address as president

^a Snell, Simeon, President's address delivered at the seventy-sixth annual meeting of the British Medical Association: *Brit. Med. Jour.*, Aug. 1, 1908, p. 243.

of the British Medical Association in 1908, described experiments made with the assistance of Dr. A. Stokes, a Government inspector of mines, "which seem to establish the very important practical point that an underground coal worker suffering from miner's nystagmus was not able to recognize the 'cap' which forms on a safety lamp in the presence of fire damp." As, under given conditions, it is desirable to recognize a quantity of gas smaller even than 2 per cent, the implication was that miners suffering from nystagmus in dangerous mines requiring the constant use of safety lamps should not properly be intrusted with their respective duties. According to the editorial in the *British Medical Journal*,^a —

The disability to see the "cap" is due to the fact that the oscillations of the eyeballs give the sufferer the impression that the object looked at is in motion; he sees his safety lamp and its flame as if moving, or "dancing," as he expresses it. The more rapid the oscillations the more rapid the apparent movement of the lamp, as the oscillations may vary from 100 to anything up to, say, 350 in a minute, the apparent movements of the safety lamp may be very quick indeed, producing little more than the appearance of a blur of light. The oscillations may be to-and-fro, or rotary, or the two may be combined, but rotary movements are seldom, if ever, absent, and a miner frequently describes the safety lamp as appearing to move rather more in an eclipse than in a circle. The nystagmus is arrested by turning the eyes downward, but in searching for fire damp the examiner must give particular attention to the roof, and consequently must often look up when lying or stooping in a very constrained attitude.

The foregoing discussion was evidently intended to emphasize the necessity for medical examination, particularly with reference to the claims for compensation made on account of nystagmus in recent years in the United Kingdom. According to Llewellyn,^b 1,618 men suffering from miners' nystagmus received compensation in the United Kingdom in 1911. The subject was therefore shown to be one of fairly considerable importance to the mining industry. Even more important was the final conclusion, that "were it established that nystagmus in the 'deputies' or 'firemen' [equivalent to fire bosses in the United States] whose duty it is to search for fire damp was even an occasional cause of explosions, the arguments in favor of systematic medical inspection would be greatly strengthened."

FACTORS OF CAUSATION OF NYSTAGMUS.

The conclusions of Snell were not new to those familiar with the subject. As far back as 1891, the *Medical Record*^c of New York contained a statement to the effect that—

Dr. Snell persists in his opinion that there is no reason for supposing that nystagmus or the nervous disease which manifests itself in a morbid winking of the eye, so common among miners, is attributable to working by the imperfect light of the safety

^a Apr. 13, 1912, p. 853.

^b Llewellyn, T. L., A lecture on miners' nystagmus. Delivered at the Mining Machinery Exhibition, London, on May 31, 1913: *Brit. Med. Jour.*, June 28, 1913, p. 1359.

^c Anonymous, Morbid winking by miners: *Medical Record*, Oct. 10, 1891, p. 468.

lamp. The fact that the complaint is found among the workers with naked lights is in itself sufficient to throw doubt upon the long-prevalent theory. The Government inspector of mines for the Midland District notes, on Dr. Stoke's authority, the case of a man who, after working with the Davy lamp for 14 years without injury, proceeded to work at a pit where candles were used. He had been employed there for some three and one-half years, and during the last 12 months he experienced symptoms of nystagmus, and had ultimately to leave work and seek medical aid. Dr. Snell has collected a mass of facts and a record of a large number of instances of men suffering from the infection, which will, he believes, be very corroborative of the views he has before set forth, namely, that the prime cause of the affection is to be found in the position assumed by the miner at his work.

OPHTHALMOLOGICAL TESTS.

In 1908 the Engineering and Mining Journal ^a contained an article on the subject, bearing also on the investigations of Dr. Snell, briefly summarized below:

A miner with nystagmus when looking at a safety lamp gets the impression that the object looked at is in motion. This is caused by the oscillations of the eyeball, and is due to the weariness of the elevators of the eyes caused by working in constrained positions in the mine.

Forty-eight miners were tested in the ophthalmoscopic dark room in the Sheffield hospital. These men were brought from 13 different collieries and were examined with regard to their capacity to detect the "caps" of safety-lamp flames. All of these men failed to detect a "cap" until a dangerous amount of gas was present. One could not see a large "cap" at all. He said his lamp was "spinning too much"; another could not see a "cap" until he steadied his eyes. He then saw a 1-inch "cap." One who had nystagmus in a marked degree reeled like an intoxicated man when rising from the floor from the kneeling position he had assumed in reading the lamp. The lamp was full of gas before he detected a "cap."

The results of the experiments were so astonishing that members of the association now advocate the periodical medical examination of all officials whose duty it is to make the daily gas tests in coal mines. Each inspector should be tested for vision as carefully as locomotive drivers and signalmen. Gas tests with the safety lamp are almost useless unless the testor has good vision. It might be valuable if the question of vision would be investigated by the Accident in Mines Commission, now sitting in Pennsylvania.

The suggestion that the subject should be investigated by the Accident in Mines Commission of the State of Pennsylvania was not carried into effect.

The technical aspects of astigmatism and visual acuity are extremely involved and do not permit of an extended discussion on this occasion. The following extract, however, from an address on miners' nystagmus by Shufflebotham ^b is included as suggestive of the direction in which inquiries of this kind are most likely to be practically useful:

Visual acuity is nearly always diminished, even in convalescent cases where there is no oscillation of the eyeballs. In severe types of nystagmus where the oscillatory

^a Eng. and Min. Jour., Mar. 21, vol. 85, 1908, p. 1012.

^b Shufflebotham, Frank, Miners' nystagmus: Brit. Med. Jour., Mar. 21, 1914, p. 650.

movements of the eyeballs are constant, it is impossible to estimate the field of vision. Out of between 60 and 70 cases of coal miners' nystagmus Cridland found it possible to take the field of vision in 25. Nearly all the patients he investigated were men who had been compelled to give up their work on account of the severity of the symptoms. The results of his examination of these cases showed—

1. That contraction existed for white, blue, and red in practically all the cases examined.

2. The contraction was of concentric type and symmetrical in shape, although not always in depth.

3. In the majority of cases the colors were in their correct order, but occasionally interlacing of the red and blue occurred, the correct order being recovered as the case improved.

4. The contractions for red and blue were generally greater than those for white and rather greater for red than blue.

5. By grouping the cases into mild, moderate, and severe types the fields broadly showed corresponding contractions.

6. Speaking generally, as the disease improved the fields of vision improved, but contraction persisted as long as any subjective symptoms were present and although oscillatory movements could not be elicited by any test.

7. Most of the cases showed more or less marked signs of such symptoms as clonic spasm of the eyelid, twitching of the neck, etc., but there seems to be no direct relationship between the presence and the degree of these signs.

AMERICAN INVESTIGATIONS.

The question, however, was taken up by the Illinois Commission on Occupational Diseases, which made its report ^a under date of January, 1911.

The following is our report of our investigation of miners' nystagmus in the State of Illinois. Two factors are operating to make this disease less frequent. Firstly, the condition is limited to pick miners, and they are becoming less numerous yearly on account of the increase of machine mining. The following figures, taken from the Illinois Coal Reports for the year ended June 30, 1908, show the percentage of machine mining: Total quantity of coal mined by hand, 34,062,029 tons; total quantity of coal mined by machine, 15,210,425 tons, or over 30 per cent; total number of men employed about the mine in all capacities, 70,841; total number of men employed in actual mining, 46,194; total number of men employed in machine mining, about 16,000; total number of pick men, 30,194. From the foregoing we see that of the total of 70,841 employed only about 30,194 [or 42.6 per cent] belong to the class of workmen subject to miners' nystagmus.

Secondly: The disease is confined to those pick men who work with the eyes in an unnatural position; that is, looking upward and to one side. Previous to the passing of the gross-weight law some years ago, the men were paid only for coal which would pass over a screen of a certain size. This caused the men to do a lot of overhead pick work in order to obtain the coal in large pieces. The gross-weight law forced the owners to pay for the entire quantity mined, and the miners now assume a more natural position. Of the 30,194 pick men in Illinois, we examined the eyes of about 500, or one-sixtieth of the entire number, without finding a single case. Two men had complained of subjective symptoms of the disease in the past, but at the time of the examination showed no objective symptoms.

^a Lane, Francis, and Ellis, J. B., Report of Commission on Occupational Diseases; Miner's nystagmus, 1911, p 155.

Conclusions.—The disease is rare, and, owing to the passage of the gross-weight law and the increase of machine mining, it is becoming less frequent in the State of Illinois. The only cure is cessation of the occupation which caused it.

The conclusions of this investigation were negative, but the investigation was seemingly not made with the required degree of scientific thoroughness.

FREQUENCY OF NYSTAGMUS IN ENGLAND.

A further original investigation was made by Butler,^a honorary ophthalmic surgeon to the Coventry and Warwickshire Hospital.

Butler points out that—

In all colliery centers miners' nystagmus is a common disease. It is scheduled under the act of 1906 as a condition for which a miner may claim compensation, and so a knowledge of its leading characteristics is essential to all medical men practicing in such a district. The average ophthalmic textbook devotes only a few lines to the affection, and even the meager information given is apt to be somewhat dogmatic and inaccurate.

Butler further states that the symptoms in a severe case are characteristic, and briefly describes them as follows:

The eyes oscillate violently, the eyelids twitch, and the man appears to be, and often is, in a state of great nervous agitation. When his visual acuity is tested with the types it will generally be found to be as low as one-tenth of the normal. He is quite unable to read or to continue at his work, and will frequently complain that he can not see his way about in the dark. But such a violent attack is uncommon, and it will be, therefore, proper to consider in detail the more useful manifestations of the affection.

The history is typical. The miner has almost invariably worked some years in the pit, and has in most cases been a "holer," one who lies on his side and undercuts the seam of coal. He first notices that at the end of a day's work the lights begin to "dance." They may dance vertically, horizontally, or in a circular fashion like a Catherine wheel. He can for a time overcome this oscillation by looking down and resting his eyes. Soon, however, the dancing commences earlier in the day, and he more frequently has to "steady" his eyes, and finally the lights begin to dance as soon as he enters the mine, and work becomes impossible. At this period the subjective sense of movement may cause vertigo.

In the early stages of miners' nystagmus the sufferer is free from trouble when he leaves the pit, but as the disease progresses nystagmus is present when it grows dark and the street lamps are lighted. Eventually nystagmus is always noticed, even in daylight.

At the beginning of the case nystagmus commences only when the eyes are considerably raised, then it appears as soon as the gaze rises above the normal plane, and later it ceases only when the subject looks down. In fact, the severity of the attack can be accurately gaged by the angle above or below the primary position at which nystagmus can be elicited. The position of the head, however, has nothing whatever to do with the matter; nystagmus can be demonstrated just as easily in the supine posture if the eyes be directed toward the brows as it can in the erect. Peters is quite incorrect when he states that nystagmus ceases if the head be thrown back. It does so in many cases if the patient looks at the same object, but if he moves his eyes back *pari passu* with his head nystagmus does not cease.

^a Butler, T. H., Miners' nystagmus: Brit. Med. Jour., Mar. 5, 1910, pp. 558-559.

In a slight case, or one which is in process of cure, it may often be impossible to detect any nystagmus by simply raising the eyes. Reid has taught us that if we rotate the patient several times, until he is a little giddy, and then direct his eyes to the ceiling, nystagmus may appear. If we can produce no nystagmus by this method it is safe to assume either that the case is not one of nystagmus or that it has been cured.

The direction of the nystagmus may be vertical, horizontal, or circular. In my own practice the vertical variety has been rare. One eye may have a different kind of nystagmus from the other.

Hemeralopia may be present. Court found it in 127 cases out of 164; Dransart detected it in 5 per cent of his patients. Romi   states that he has never seen this symptom, although he has examined several thousand individuals. My own experience has been that night blindness is undoubtedly a symptom of the disease. Probably at least 25 per cent of all cases are unable to see in the dusk.

Visual acuity is unaffected when the eyes are at rest. If the types be placed on the floor level and the miner stand upon a chair, he may read the last line; if he sit down and the types be hung on the wall, he may fail to read the top line.

The "holing" mentioned by Butler is somewhat at variance with American mining practice and has been described as follows in an address on miners' nystagmus by Frank Shufflebotham:^a

Symptoms of nystagmus are most commonly found among miners engaged in holing, a process which consists of cutting the coal seam so as to get out the coal in pieces as large as possible. The holer lies on his side with his knees drawn up and his head thrown backward, and he strikes the coal with a horizontal swing, the lamp being placed near his feet. He may undercut the seam or "top cut" it, but in either case the muscles of the eyeballs are continually in a strained position, generally in an upward or oblique direction. As a result of this eyestrain the elevator muscles suffer from strain and cramp. Similar effects are found in other muscles, producing wry neck, twitching eyelids, and tremors of the head. Holers as a class are undoubtedly more predisposed to nystagmus from the nature of their constrained work; hewers and the loaders who are working at the face come next in the liability to the onset of the disease.

TYPICAL CASES.

The symptoms and personal history of the disease have been quoted in full on account of their unusual practical value. Nystagmus unquestionably is often mistaken, at least in its initial stages, for ordinary eye afflictions; for, as observed by Butler,^b the average ophthalmic textbook devotes only a few lines to the affection, and much of the information is dogmatic and inaccurate. It has therefore seemed proper to add the following description of a typical case, presented by Butler^c at a meeting of the Coventry division of the British Medical Association in 1910.

T. R., aged 45, was a miner in the Newdigate colliery, a lamp mine; had been a miner all his life.

About six months ago he began to notice that the lamps were dancing up and down. He had to sit down and "steady" his eyes. Three months ago, when he was examining

^a Shufflebotham, Frank, Miners' nystagmus: Brit. Med. Jour., Mar. 21, 1914, pp. 348-349.

^b Butler, T. H., Miners' nystagmus: Brit. Med. Jour., Mar. 5, 1910, p. 558.

^c Butler, T. H., Op. cit., pp. 558-559.

the roof, a piece of coal fell upon his nose and cut his face. Had he not had violent nystagmus he would have seen that a large fragment was loose and would have avoided it. After the accident the nystagmus got much worse. He sees very badly at night, not only because everything is in motion, but because there is a "sort of mist before his eyes." He sees a little better if he looks down, but not so well as his mates do. In fact, he has slight hemeralopia.

Condition when first seen: Violent nystagmus and twitching of lids. Vision=6/60. Advised to give up his work underground entirely and permanently.

Condition a month later: The eyes were normally at rest, but if he looked at an object fixedly for a few seconds his eyelids began to blink and twitch violently and he looked away as though shielding his eyes from a dazzling electric arc. As soon as he looked upward violent twitching and vertical nystagmus commenced.

$$\begin{array}{l} \text{R. V.} = 6/60c \frac{-3.5}{-2} = 6/9. \\ \text{axis horizontal} \\ \text{L. V.} = 6/60c \frac{-3}{-1} = 6/9 \\ \text{axis horizontal} \end{array}$$

The fundus was normal, but could be seen only with great difficulty on account of the twitching of the lids. He was unable to read even when he looked down.

The patient subsequently improved considerably, but he can not do any work, for as soon as he looks fixedly at an object the oscillations commence.

OCCUPATIONAL PREDISPOSITION.

Butler ^a properly observes that this is a most instructive case. In the first place, he points out, it shows the classical symptoms, which have been ameliorated but not cured by rest. Before the compensation act this miner would have been discharged and left to take charge of himself as best he could; under the act of 1906, however, the coal-mining corporation was responsible for the disease and had to provide for his needs. In this case also nystagmus conduced to an accident and the accident aggravated the disease. As regards the etiology of nystagmus, or the causative factors responsible for the occurrence of this affliction, Butler ^b states that—

The textbooks say that it is strictly comparable to scrivener's palsy, due to cramp of the elevator muscles of the eye. This is the theory enunciated by Snell, by Nieden, and by Dransart; it was for long accepted without criticism or challenge, and has been copied from book to book, rather as a proved fact than a hypothesis. To be brief, the view that the miner is always straining his eyes upward, producing muscle fatigue, which results in nystagmus, does not account for the facts. First, the miner does not strain his eyes upward; like other sensible mortals, he makes himself comfortable and moves his head, not his eyes; secondly, there is no proof that any muscle fatigue exists, and conclusive proof that it does not; and, finally, if muscle fatigue did exist, it would produce a tetanic and not a clonic spasm. Nystagmus is essentially a disease of the collier; it is not found in metal mines, where men work under similar conditions to those obtaining in coal mines, but with one great difference—the metal mine is not bounded by glittering black walls.

^a Butler, T. H., *Miners' nystagmus*: Brit. Med. Jour., Mar. 5, 1910, p. 559.

^b Butler, T. H., *loc. cit.*

SAFETY LAMPS AS A CAUSE OF NYSTAGMUS.

In this connection Butler ^a makes the interesting observation that the disease was first described at the time when the Davy lamp was introduced, and that as soon as the use of safety lamps was enforced by law it became frequent. In his own words, as soon as the illumination of the miner's candle, which gives 0.5 candlepower, was replaced by that of the Davy lamp, with its feeble glimmer of 0.28 candlepower, cases of nystagmus became increasingly frequent. The miner's lamp has been improved now and the disease is much less common than it was. The ordinary lamp used in England in 1910 when clean has a candlepower of 0.44, but as it gets covered with dust and the wick chars its light falls off rapidly. ^a

The method of amelioration is, therefore, suggested by this remark, in that it should not be difficult to insist, if necessary by law, upon the keeping of the safety lamps not only locked but also clean, so as to provide the best possible illumination.

MINE DARKNESS AS A CAUSE.

In concluding his interesting and valuable contribution to the subject of nystagmus, Butler ^a refers to the claim that darkness is primarily a cause of nystagmus. This, he insists, can not be so, as employees in photographic studios, who work for hours in absolute darkness, do not contract nystagmus, nor do boiler makers and other artisans who work by feeble light. He therefore holds that the only theory that can explain the disease is that suggested by Reid, of Nottingham, and Nuel, of Belgium, that it is a disordered cerebation, or, in other words, a defect in the brain and not of the eye muscles. It is produced, according to this view, by the peculiar work of the miner, the long-continued rhythmic movements of the pick in comparative darkness. Finally, the argument is advanced that the attempt on the part of Snell to show that compositors and other workmen occasionally acquire occupational nystagmus will not stand the test of a critical examination, which would lead to the conclusion that these men did not suffer from true miners' nystagmus, but that the disease always was, and still continues to be, the special disease of the colliery.

ERRORS OF REFRACTION AS A CAUSE.

This address led to considerable correspondence, which brought out some additional phases not fully discussed by Butler and some controversial views of considerable practical importance. A letter

^a Butler, T. H., Miners' nystagmus: Brit. Med. Jour., Mar. 5, 1910, p. 559.

by Carruthers,^a assistant medical officer of health of the county of Derby, follows:

SIR: I notice that, when discussing the etiology of miners' nystagmus (Mar. 5, p. 558), Dr. Harrison Butler did not suggest an error of refraction as a possible predisposing cause, although the case which he describes shows this. I mention this because I know that as a body miners systematically neglect their eyesight, this fact having been forcibly brought home to me during the last few months whilst examining school children in a mining district, the parents simply stating that if their child had to wear glasses he would not be allowed in the pit. I understand that at present no examination of the eyes is required by the owner before a man is employed as a collier; and surely, if evidence could be produced to show that a definite relationship exists between errors of refraction and miners' nystagmus, the owners for their own protection would soon insist on such an examination.

Dr. Harrison Butler states that there is no muscle fatigue (of the eye) when the man is at work; but during such heavy work, when practically all the man's muscles are in use, how can those of the eye escape the general fatigue of the body? If, in addition, a serious error of refraction exists, which of itself would lead to strain, this would be especially noticeable at the end of the day's work, the time when the nystagmus first appears; and I suggest that the nystagmus is akin to the physiological tremor of the hands which many people have after great physical exertion, but that, of course, it quickly becomes pathological as the conditions develop.

It may be asked why, if these arguments are correct, miners' nystagmus does not occur as soon as the man becomes a collier? But then his tissues are young, and can overcome the strain imposed upon them, and it is as he gets older and is still subjected to the same conditions of very heavy work in a poor light and in a bad position that the strain is felt and nystagmus shows itself.

Ashforth^b later contributed a brief statement which is also given in full:

SIR: The only excuse I can offer for entering on this subject is that I live in a colliery district. Whether the fact that Dr. Harrison Butler did not mention errors of refraction as a cause directly was simply an error of omission, or whether he considered it a contributing cause, but thought it unnecessary to state, I think, matters very little. As in other discussions, one is very apt to believe greatly in himself and his own limited experience, for limited it is.

Dr. Carruthers, so far as I can judge, has simply concluded that miners neglect their eyesight because a few parents have said something about their children and the pit. Now that would lead one to think nystagmus was a modern disease or ailment; but I am certain Dr. Carruthers will agree it is not. As it is, some people avoid glasses because of the compensation act. Again, this act is new (comparatively), and can not account for nystagmus before the act, because miners would have no fear about wearing glasses or having their eyes examined. I agree with Dr. Harrison Butler that there is no muscle fatigue of the eye, and disagree with Dr. Carruthers when he suggests that all the man's muscles are in use. I agree that a serious error of refraction may contribute, but I do not believe it to be the cause; personal experience in colliery districts has not taught me so. It is not safe to compare or draw an analogy between nystagmus and a physiological tremor of the hands.

As to the tissues being young and able to resist, I may state that all the cases I have seen have been men under 40; some I have seen over 50, but they are not so numerous.

In conclusion, might I suggest that the cause might as easily be found in the retina as anywhere else?

^a Carruthers, W. D., Miners' nystagmus: Brit. Med. Jour., Mar. 12, 1910, pp. 666-667.

^b Ashforth, T. L., Miners' nystagmus: Brit. Med. Jour., Apr. 9, 1910, pp. 901-902.

In reply to these two letters, Butler ^a made answer as follows:

SIR: I unfortunately did not notice Dr. Carruthers's letter in the Journal of March 12 at the time. It would appear likely that an error of refraction would be a predisposing cause, whether one regarded the disease as a fatigue cramp or as a loss of coordination due to partial loss of fixation. But supposition and theory must bow to fact, and the fact is that errors of refraction are found among nystagmic miners in exactly the same proportion as among the rest of the population. Some of the worst cases I have seen have been emmetropic, and have shown no error of muscle balance, so we can only conclude that errors of refraction have nothing to do with the matter. This is not the place to discuss with Dr. Carruthers the etiology of the disease. He will find the whole question argued out in my paper on the subject in *The Ophthalmoscope*, to which I alluded in my article published on March 5. At the end of this paper there is a full bibliography dealing with the subject. I would recommend him to read Dr. Reid's paper in *Brain*, and then to examine a long series of cases for evidence of muscle strain. The case published in the Journal of April 16 is almost positive proof that cramp of the elevators has nothing to do with the production of the disease. In this highly interesting case nystagmus appeared only when the miner looked down.

These letters bring out the imperfect status of the whole question as regards the essential points of material importance, not only to the physician and the miner, but also to the mine manager and the courts called upon to pass judgment in the arbitration of cases of workmen's compensation.

FATIGUE OF VISION AS A CAUSE.

The British Medical Journal also reports an animated discussion regarding nystagmus, between Romi   and Thiebert, both of Li  ge, and Moret, of Charleroi, Belgium.^b The two former concluded that miners' nystagmus was due to insufficient lighting, was benign in nature, and rarely interfered with ability to work. They strongly objected to the theory that nystagmus involved an increased liability to accident. Moret discussed the causation, concluding that the infection was a neurosis produced by ocular fatigue due to darkness, combined with fatigue of the muscles, notably the elevators, from the strain of looking in an abnormal direction. A number of French representatives insisted on the risk of accident from this condition, and Shufflebotham^c pointed out that nothing had been said respecting the subjective and objective symptoms that occurred apart from the ocular symptoms.

The foregoing discussion aroused considerable interest and resulted in several important papers by qualified authorities familiar with the actual facts of the existing situation in the United Kingdom. Elworthy,^d inspector of injured workmen to the Ebbw Vale Co., read a paper on miners' nystagmus before the Monmouthshire Division of the British Medical Association. After first pointing out that miners'

^a Butler, T. H., Miners' nystagmus: *Brit. Med. Jour.*, Apr. 23, 1910, p. 1024.

^b Report of International Congress on Diseases of Occupation: *Brit. Med. Jour.*, Oct. 1, 1910, p. 980.

^c Shufflebotham, F., Miners' nystagmus: *Brit. Med. Jour.*, Oct. 1, 1910, p. 980.

^d Elworthy, H. S., Miners' nystagmus: *Brit. Med. Jour.*, Nov. 19, 1910, pp. 1577-1580.

nystagmus is a disease peculiar to coal miners, and that on the basis of personal inquiries, no cases had been found to occur in the Cornish tin mines nor in the lead mines of the Isle of Man, Elworthy replies to the question as to why it is that nystagmus occurs only in coal mines, to the effect that it is the entire absence of color that makes all the difference in the underlying conditions responsible for its frequency among colliers. He ^a remarks that—

I take it that the cause is fatigue of the eye, resulting from working by artificial light with a black background and nearly black surroundings. There is the blackish "rub-bish" or "slack" above and below the coal, and the jet black coal with some sparkling facets which reflect the light. The monotony is not relieved by other colors. The miner may come to work with clean face and clothes, but in a few hours all is more or less black from the dust. Then he has to fix with his eye the point at which to strike with his mandril or to lift out lumps of coal against a black background. When he turns his eyes away from the coal there is no color relief. To make matters worse, the majority of miners prefer to work in the day. The consequence is that for the greater part of the year it is dark when they get up and go to work; they work in the dark, and in winter it is dark soon after they come out. They therefore get the minimum of daylight, and the opportunity of seeing a variety of colors by daylight, which means physiological relief to the eye.

This is rather a novel point, not emphasized by the earlier authorities; but as another cause of fatigue to the eyes, he points out that when the miners have to walk a mile or more underground to reach the face where they work, "they proceed more or less in single file, each carrying a lamp which gives out light in every direction," with the result that "the miner walking behind another gets the glare of that lamp in his eyes all the time. * * * Then, after working his eight hours and his eyes being more or less exhausted, he has to make a similar journey back." On inquiry, Elworthy found that the men feel the effects of nystagmus most when returning from work with the intense glare of the lamp just in front of them, and many find it necessary to sit down and wait until the effect disappears.

OBLIQUE NYSTAGMUS.

As regards the theory that nystagmus was produced by working in a lying-down position, Elworthy was not in a position to give an opinion, as in the great majority of the mines of the Ebbw Vale district the colliers work in an upright position. He therefore had not seen a single case of oblique nystagmus. He, ^b however, points out that other underground workers, such as haulers, timbermen, and repairers in coal mines also acquire nystagmus, and that the only class that seems immune is hostlers, which he attributes to the fact that the underground stables, as a rule, are whitewashed. He therefore concludes that the only essential factor seems to be exhaustion of the eyes from working in the general blackness without any color relief.

^a Elworthy, H. S., *Miners' nystagmus*: Brit. Med. Jour., Nov. 19, 1910, p. 1577.

^b Elworthy, H. S., *Op. cit.*, pp. 1577-1580.

The discussion by Elworthy included the pathology, symptoms, and course of the disease, the varieties, diagnosis, prognosis, and the treatment of nystagmus in the light of practical experience, including the results of an analysis of 100 cases. All that he has to say is of unusual practical interest, except that with reference to pathology he limits himself to the statement that he is ignorant about the minute changes in the retina, or nerve centers of the orbital muscles. He says:^a

What seems to me to occur is, when a certain stage of exhaustion is arrived at, co-ordination is lost and spasm sets in; very much the same as in writer's cramp or other trade neuroses. Lastly, accommodation fails. The spasms are clonic, and may be regular or irregular, and confined to two opposing muscles or affecting more. In some cases the whole head is in a state of tremor. In the early or "latent" stage, although there are movements of the eyes, there is sufficient power of accommodation to prevent confusion of vision, but sooner or later this accommodation fails.

SYMPTOMS AND COURSE OF THE DISEASE.

As regards the symptoms and course of the disease, Elworthy^a states that:

Nystagmus seldom manifests itself until the miner has been working for some years. In the case of boys getting it there may be some refractive error or hereditary element. One boy I examined, aged 15, who got nystagmus after working three years, was the son of a collier who admitted having had trouble with his eyes, but had not been on compensation for it.

The first stage of the disease may be called latent nystagmus. The patient may be perfectly unconscious that he has anything wrong with the eyes, although nystagmic movements may be quite obvious and definite. One case I examined for an injured back, and who then had nystagmus, worked ten months before being certified for it; another who also injured his back over two years ago has not yet been certified; so that as long as the disease remains in the latent stage, unperceived by the patient, it does not seem to interfere with his work. I do not know how long this may continue, or whether the movements are continual or only periodic.

There is in many cases a general and increasing nervous irritability, and then a blow or sudden fright is sufficient to break down the coordination of the ocular muscles, and the power of accommodation to see with moving eyes is lost. The man then discovers that he has nystagmus.

When the disease comes on naturally the first symptoms may be various. In some it is the lamps that seem to move or become blurred, or he becomes dazzled by them; in others headache or pain in the eyes, or else everything becomes misty and he is lost in a fog.

When movements are well developed everything seems moving about, and he becomes giddy and staggers. Bending down or sudden movements increase the trouble; so does fright. A man may be able to walk about the street well enough, but if a dog barks or if some one shouts at him he is immediately lost in a fog and staggers about quite unable to see what is coming or where he is going. Hence the danger of such men working in mines.

The most constant symptoms are headache, giddiness, and movements. My records are far from complete, and I find only 43 per cent with these three symptoms noted;

^a Elworthy, H. S., Miners' nystagmus: Brit. Med. Jour., Nov. 19, 1910, p. 1578.

but my impression is that fully 60 to 70 per cent have them all. Giddiness and movements, but without headache, also occur, and I find 7 cases with the definite record of no headache and 6 in which headache is not mentioned. Of these 13 cases, 8 were rotatory, 4 lateral, and 1 mixed.

Intolerance of light and continual headache are frequent, and in severe cases the man can sit about only with his eyes shaded and his back to the light. In such cases there may be an error of refraction as well.

One variety often passes into another, a rotatory to a lateral, or vertical to a rotatory with nictitation. Nictitation often comes on late, and may be the last objective symptom visible, but in some cases it is present early, with very indefinite movements of the eye.

The two eyes may be equally affected, or have different movements, one lateral the other vertical or rotatory, but I have never seen two eyes rotating in opposite directions.

The greatest discomfort and pain in the head is caused by the very fine and quick movements, and the least by the slower rotatory. An error of refraction may cause persistent headache, and delay recovery unless corrected by proper glasses, which, however, can not be worn in the pit.

In this connection the following observations by Shufflebotham^a regarding the symptomatology of miners' nystagmus are of interest:

In miners' nystagmus we are dealing not with a disease localized to the eyes, but with a general disease one symptom of which is oscillation of the eyeballs. I believe that the term "miners' nystagmus" is unfortunate, as it simply relates to one symptom of this complaint, and the symptoms are not confined to oscillation of the eyeballs and effects resulting from this phenomenon. There may be, and generally are, symptoms such as headache, nausea, attacks of giddiness, muscular tremors, twitching of the muscles in different parts of the body, especially the muscles of the eyelids and the face and the neck; neurasthenia may be a prominent symptom, with its associated conditions, such as a quickened pulse, exaggerated reflexes, increased vasomotor irritability, sleeplessness, and nervous depression. All these symptoms may be present in any case of miners' nystagmus, but in many cases only some of them are present, and at given times the prominent symptom—the oscillation of the eyeballs—may actually be absent, although the patient is undoubtedly suffering from this disease.

VARIETIES OF NYSTAGMUS.

These observations and conclusions in a general way are confirmed by other authorities, but in the work cited they are set forth with unusual clearness and therefore are quoted in full. It also seems advisable to cite in complete detail the seven varieties of nystagmus as observed and defined by Elworthy,^b as follows:

1. *Lateral*.—An alternating clonic spasm of the internal and external recti.
2. *Vertical*.—An alternating clonic spasm of the superior and inferior recti.
3. *Rotatory*.—An alternating lateral and vertical nystagmus in regular sequence producing rotation. In one case with a large and flaccid eye it was quite easy to see the tug of the several rectus muscles at their insertions into the globe.
4. *Mixed*.—An alternating lateral and vertical nystagmus in irregular sequence, producing rotation but irregular movements.
5. *Oblique*.—Presumably a synchronous contraction of a superior with one of the lateral recti alternating with the inferior and the opposite rectus. It could also be

^a Shufflebotham, Frank, Miners' nystagmus: Brit. Med. Jour., Mar. 21, 1914, p. 649.

^b Elworthy, H. S., Miners' nystagmus: Brit. Med. Jour., Nov. 19, 1910, p. 1578.

produced by the two oblique muscles if the deviation of the axis is not corrected by the recti.

6. *Axial rotation*.—Alternating spasm of the superior and inferior obliques, with no deviation of axis. I have one case, which seems the most remarkable of the series. Coordination of the recti had not broken down, otherwise there would have been oblique nystagmus. But the only movement visible was rotation on the antero-posterior axis.

7. *Nictitation*.—Clonic spasm of the orbicularis muscle. Generally associated with some other movement, but sometimes present alone. As it occurs with considerable frequency, I think it should be classed as a variety of nystagmus.

With reference to diagnosis, he points out that this is easy enough in the majority of cases. As emphasizing, however, some of the practical difficulties of exact diagnosis, the following case is quoted in view of its bearing upon problems of workmen's compensation.^a

I had one case of the indefinite class, who received compensation for a considerable time, and who was admitted to a hospital for some intracranial disease from which he eventually died. No nystagmus was observed while he was in hospital, but he had optic neuritis. This man was certified on subjective symptoms only. It is all very well to certify cases on subjective symptoms just because a man happens to be a collier, but it is very difficult to disprove a claim for compensation if there are these indefinite symptoms, which may, after all, have nothing to do with miner's nystagmus.

ANALYSIS OF CASES.

The results of an analysis of 100 cases are briefly summarized in the statement that the average age at the commencement of the disease was $35\frac{1}{2}$ years; the average number of years a man had been working underground was $21\frac{1}{4}$ years; and the average period between the first indications of nystagmus and the ultimate and subsequent leaving of work was 8 months. This average, however, included three cases with an exceptionally long duration of 2 to 8 years, and if these are excluded the average period was $6\frac{1}{2}$ months. The average subsequent period of disability for all cases was 5 months, but as this included latent and uncertified cases, the average is rather an underestimate. A number of men resumed work on the surface before complete recovery. The longest period of disability was 28 months, without recovery. The shortest was 3 weeks. There were 18 latent cases, and of these, 8 first noticed nystagmus after a blow on the head; 1, after a blow on the head but without becoming aware of nystagmus until 16 months later; 5, after blows on the eye or eyebrow; 2, after blows on the back; 1, after a blow on the leg; and 1, after a sprain of his side. As regards the varieties met with, the cases were classified as follows:^b

Of 14 cases in which nictitation was a prominent symptom, those with some other movement, such as vertical or lateral, are included in those classes, and those with no definite movement except nictitation in the indefinite. There were: Rotatory, 27 cases; lateral, 25; indefinite, 18; vertical, 12; mixed, 12; not recorded, 5; axial rotation, 1; oblique, 0; total, 100.

^a Elworthy, H. S., *Miners' nystagmus*: Brit. Med. Jour., Nov. 19, 1910, p. 1578.

^b Elworthy, H. S., *Op. cit.*, p. 1579.

ADEQUATE TREATMENT AND PERMANENT CURE.

Coming to the important question of prognosis, Elworthy^a remarks that although his experience had been rather limited he found that the men who remained at work for months struggling against the disease, until finally obliged by necessity to give up their employment, required the longest time to recover, especially if advanced in years. Given a young man who has been underground for, say, 10 to 15 years, and who applies early for treatment, say, within 2 or 3 weeks after the first indications, the prognosis is distinctly favorable, but even then 2 to 4 months will be required in summer, and a longer period in winter. According to the experience had, it was found that the sooner a man with nystagmus leaves off work the better is the prognosis, but in the early stages the diagnosis is more difficult, as there may be no definite objective symptom visible.

DURATION OF DISEASE.

As regards the relation of the duration of the disease to the variety of nystagmus, it is stated that one case of axial rotation recovered in 6 weeks; 18 indefinite cases recovered in an average of 3 months; 27 rotatory cases recovered in $4\frac{1}{2}$ months; 14 cases associated with nictitation, in 5 months; 25 lateral cases, in $5\frac{1}{2}$ months; 11 vertical cases, in 6 months; and 12 mixed cases in 8 months. The observations had not extended over a sufficient length of time to prove whether any cases were incurable. It was also ascertained that twice as many cases recovered in the 6 months from April to September as did during the months from October to March. This variation is attributed to the fact that in summer there is more daylight, and more color about the country.

On the question of relapses, it is said that—

One would expect that as coal mining produces the disease, so resuming work underground would produce relapses. How many of these cases will relapse, or how long it will take, I do not know. I have not had time to see yet. For the 7 cases of relapse included in the 100 the average time from resuming work to the relapse was 12 months. Two more have been observed with recurrence, but have not ceased work. One of these is now 2 years after resuming. The variety of nystagmus in a relapse is not always the same as in the first attack.^a

SUBJECTIVE TREATMENT.

The importance of subjective treatment is first considered under preventive measures; and, second, from the strictly medical aspect. On the assumption that the direct cause of nystagmus is a complete absence of color in coal mines, the argument is advanced that^a—

The importance of daylight seems to have been overlooked both by the miner and the employer. I take the view that, as far as nystagmus is concerned, working underground in daytime is a mistake, as the miner in doing so loses his opportunity of

^a Elworthy, H. S., *Miners' nystagmus*: Brit. Med. Jour., Nov. 19, 1910, p. 1579.

refreshing the eye by looking at colors in daylight, and so, in a measure, compensating himself for working by artificial light without color relief.

To get this relief, the hours of work might be altered somewhat as follows:

Start work at the pit head.....	4 a. m.
Come out.....	12 midday.
Allow an hour to get home at.....	1 p. m.
Recreation and see the world till.....	6.30.
Bed.....	6.30 to 2.30 a. m.
Breakfast and get to pit head by.....	4 a. m.

He would thus get some four or five hours of daylight all the year round, which is of far more value to the eye than artificial light.

METHODS OF IMPROVING ILLUMINATION.

It is further suggested that to prevent unnecessary fatigue to the eyes removable shades should be provided for the lamps, so that the light will be given out in the front only. Such lamps should be used in going in and out of the mines. When at the face, it is suggested the shades could be taken off, so that the light would not be interfered with. Finally, the suggestion is made that some sort of color scheme should be introduced into coal mines so as to bring about conditions as good at least as in lead mines. In brief, according to Elworthy,^a as the essential cause of nystagmus is absence of color, the one rational preventive measure is the substitution by artifice of sufficient color to compensate for the deficiency. It is therefore proposed that the roof, the leeward sides of the posts and collars, and the cogs and sides of the alleyways be colored with some light but inexpensive wash, whitewash, or, preferably, green or other varied colors. It is realized that this would have to be done daily on account of the dust in the mine, and although this would be expensive, it is pointed out that compensation for nystagmus cases is itself a serious element of management expenses. The argument is advanced that—

If a quarter of the sum lost through nystagmus were spent in continually coloring the mine, and was enough to bring its color relief up to the level of a lead mine, I do not see why nystagmus should not be abolished, and the other three-quarters of the loss wiped out.^b

MEDICAL AND MECHANICAL TREATMENT.

The recommendations regarding medical treatment are briefly set forth as follows:

The first thing to do is to remove the cause, that is, stop work underground. Let the patient rest, and in subdued light if he has photophobia.

We have to deal with a state of exhaustion and increased nervous irritability. Therefore, at first medical treatment should be sedative—such as the bromides or hyoscyanus.

^a Elworthy, H. S., *Miners' nystagmus*: Brit. Med. Jour., Nov. 19, 1910, p. 1579.

^b Elworthy, H. S., *Op. cit.*, p. 1580.

Later these should be replaced by stimulant tonics and brighter light as he can tolerate it. To commence with stimulants seems to me like whipping up a tired horse instead of resting it.

Mechanical.—Eye shades, blue or smoked goggles, give a good deal of relief in some cases, especially in sunlight and snow, but fail in others. I should like to see other colored goggles tried, particularly green. One man recently told me that when his eyes are very painful he gets relief only on going into a green wood or field.

Proper glasses should be prescribed to correct errors of refraction.

Electrical.—I have not seen any cases that I am aware of being treated by electricity. In chronic intractable cases there seems a fair field for experiment with various forms of electrical treatment.

Special departments in hospitals.—Whether it would be profitable to provide green or other colored rooms and take in cases as patients and apply other special forms of treatment is uncertain. Very likely some way of cutting the disease short could be discovered, but, personally, I think better value for the money would be gained by the preventive measures I have indicated.^a

NYSTAGMUS AS AN ECONOMIC PROBLEM.

This extended account of nystagmus as a practical question of mine management seems to leave little room for further discussion. The importance of any occupational disease, however, is not to be measured by its numerical frequency but by its economic effect on the working capacity of the employee. In proportion as the disease incapacitates for work, the essential and economic consequences to the workmen and to the State are a matter of most serious concern. As under modern workmen's compensation the period of incapacity involves a considerable money payment to the employee, the question is also one of serious importance to mine managers. It is largely because of workmen's compensation law that the disease has attracted so much attention in the United Kingdom within recent years. Even in so complete a treatise as the *Elements of Mining and Quarrying*, by Foster,^b nystagmus is disposed of in less than eight lines. As yet most of the medical observations must be considered preliminary to a thorough, strictly scientific study of the subject. Every new contribution by a qualified medical authority adds materially to the existing knowledge of a question that is bound to assume importance in the future, not only as regards its economic aspects but even more so from the humanitarian point of view. Observations and conclusions based on actual cases are, of course, of greater practical value than conclusions resting chiefly on theoretical considerations. Browne and Mackenzie^c have published a review of 100 cases of miners' nystagmus, with observations on the etiology and treatment of the disease. The conclusions of these authors are briefly referred to in a reference to nystagmus in the treatise on occupational diseases

^a Elworthy, H. S., *Miners' nystagmus*: Brit. Med. Jour., Nov. 19, 1910, p. 1579.

^b Foster, C. Le N., *The elements of mining and quarrying*, 1903, 321 pp.

^c Browne, F. J., and Mackenzie, J. R., *The etiology and treatment of miners' nystagmus*: Brit. Med. Jour., Oct. 5, 1912, pp. 837-840.

by Thompson.^a The conclusions formed by Browne and Mackenzie,^b on the basis of 100 consecutive cases treated by them jointly, are summarized in the statement that the factors contributing to the production of nystagmus are: First, inadequate light; second, errors of refraction; third, straining of ocular muscles; and, fourth, neurotic temperament. The conclusions, in detail, are as follows:

1. *Inadequate light.*—That this is an important cause of miners' nystagmus is conclusively proved by the fact that 99 per cent of our cases had been using the lock lamp for a number of years. Only one case was found where the naked light was allowed, and here the nystagmus was accounted for by hypermetropia, much straining of the ocular muscles in narrow seams, and a markedly neurotic temperament with much physical debility.

The lock lamp must be 9 feet from the farthest point of the mandril, and so the workman is staring into comparative darkness, whereas the naked light is attached to the workman's cap or to a post close beside. Therefore, the naked light gives a much brighter and stronger light not only because it is exposed but also because the workman has its full benefit. We have also had experience with miners in various parts of Scotland, where the naked light is used, and in these districts miners' nystagmus is practically unknown.

2. *Errors of refraction.*—An examination of the summary of cases of miners' nystagmus seen by us will show that 90 per cent had errors of refraction, excluding the three cases in which there was evidence of error, but owing to marked photophobia no exact estimate could be made, while 7 per cent had normal refraction. Of the 90 per cent, 48 per cent had either myopic, hypermetropic, or mixed astigmatism; 27 per cent had simple hypermetropia; and 15 per cent had simple myopia. It is interesting to note that a large number of the cases of hypermetropia were those of comparatively young men who had worked only a few years at coal cutting.

3. *Straining of the extrinsic muscles of the eyeball.*—This is the result of the two foregoing factors. In all our cases the workman had his eyes fixed in a staring, strained position for long periods, either downward and laterally, as in narrow seams, or upward, as in wide seams; 90 per cent of our cases were engaged in cutting coal, while 10 per cent were haulers and timbermen, and one a colliery examiner.

4. *Neurotic temperament.*—The inability on the part of a very large number of men with nystagmus to concentrate their physical or mental powers in any particular line of action guides us to the conclusion that such instability is probably much more the cause than the effect of nystagmus. It most certainly appears to be a weak point in the miner's armor and would repay careful examination long before the stage of inability to work.

The severe headaches and aching eyes of which these men complain are accounted for by errors of refraction and straining of the eyes; the vertigo, by incoordination of the ocular muscles; the conjunctivitis and photophobia by the sudden frequent change from darkness into dazzling light.

AVERAGE AGE OF PATIENTS AND DURATION OF INCAPACITY.

An extremely interesting and useful table that is appended to the paper gives in detail the age, occupation, years underground, degree of refraction, oscillation, and the necessary explanations for 100 consecutive cases. Most of the men were miners and the

^a Thompson, W. G., *The occupational diseases; their causation, symptoms, and prevention*, 1914, p. 570.

^b Browne, F. J., and Mackenzie, J. R., *Op. cit.*, p. 537.

exceptions are so few that it may safely be assumed that nystagmus is exceedingly rare among other underground employees. The average age was 34.95 years, the range in years being from a minimum of 18 to a maximum of 67. The average period of underground work was 19.1 years, the range in working time being from a minimum of 2 years to a maximum of 40 years. The oscillations were very slight in 2 per cent of the cases, slight in 26 per cent, marked in 48 per cent, very marked in 2 per cent, and rotatory or marked rotatory in 16 per cent. The table follows:

Details of 100 cases of miners' nystagmus.^a

Age.	Occupation.	Time under-ground.	Refraction.	Oscillation.	Remarks.
43	Miner.....	Years. Over 30	Photophobia so marked that refraction examination was impossible.	Marked.....	Vertigo very marked.
48	do.....	36	+0.75 D. sph. in both eyes.	do.....	Nictitation and photophobia.
36	do.....	24	R. -1 D. cyl. horiz. L. -0.75 D. sph.	Slight.....	Photophobia.
27	do.....	14	R. +1 D. L. -2.5 D. sphs.	Marked.....	Vertigo and photophobia.
24	do.....	10	R. -2 D. L. -2.75 D. sphs.	do.....	
56	do.....	40	R. = Normal. L. +0.50 D. sph.	Slight.....	Vertigo frequently.
29	do.....	16	R. -0.50 D. L. -1.50 D. sphs.	Marked.....	Photophobia.
37	do.....	20	R. +0.75 D. L. +1.25 D. sphs.	do.....	Photophobia and conjunctivitis.
19	do.....	5	-2.50 D. horiz. cyl. in both eyes.	do.....	
22	do.....	8	R. 1.25 D. sph. L. +1.25 D. sph.	do.....	
29	do.....	3	-2.75 D. horiz. cyl. -2 D. cyl. axis 120°	do.....	Vertigo.
39	do.....	27	R. -0.50 horiz. cyl. L. = normal.	do.....	Photophobia and frequent headaches.
46	do.....	30	R. +0.75 D. L. +1 D. sphs.	do.....	
21	do.....	9	R. +2 D. L. +2.75 D. sphs.	do.....	Vertigo.
30	do.....	18	Simple hypermetropia, +6 D. in both eyes.	Rotatory.....	Nictitation and vertigo.
46	do.....	30	Hypermetropic astigmatism in both eyes.	Very slight.....	
23	do.....	11	Impossible, owing to photophobia.	Rotatory.....	Severe headaches.
35	do.....	(b)	R. +2.5 vert. cyl. L. +0.50 D. sph.	Very marked.....	Vertigo and aching of eyes.
28	do.....	13	Hypermetropic astigmatism in both eyes.	Rotatory.....	Nictitation and headache.
41	do.....	10	R. +1.5 D. sph. L. +1 D. vert. cyl.	Marked.....	
43	do.....	30	R. +10 D. sph. L. +10 D. sph.; 2 D. cyl.	do.....	Has been a hauler for last 10 years.
39	do.....	20	Oblique myopic astigmatism, -1 D. in both eyes.	Marked rotatory.....	Headache and photophobia.
50	Hauler.....	40	R. = normal. L. +4 D. sph.	Marked.....	
45	Miner.....	34	-1 D. sph. L. -1.50 D. sph.	Not marked.....	Nictitation and vertigo.
19	do.....	5	-0.50 D. cyl. horiz. -0.50 D. cyl. horiz.	Marked.....	Photophobia.
21	do.....	9	Mixed astigmatism in both eyes.	do.....	
38	do.....	20	Simple hypermetropia in both eyes.	do.....	
55	do.....	40	Normal. L. +2.5 D. sph.	Slight.....	Some photophobia.
21	do.....	8	Astigmatism (low degree).	Marked rotatory.....	Vertigo and photophobia.
32	Timberman.....	12	R. +4 D. sph. L. oblique hypermetropic astigmatism, marked.	Marked.....	Photophobia.
48	Miner.....	28	Oblique hypermetropic astigmatism.	Slight.....	
35	do.....	22	+2 D. sph. in each eye.	Marked.....	Severe headaches.
37	do.....	20	+1.50 D. sphs. (both eyes).	Marked.....	Vertigo and photophobia.
24	do.....	12	R. -3 D. cyl. horiz. L. -1.50 D. sph.	do.....	Photophobia.
30	do.....	15	+1 D. hypermetropic astigmatism (both eyes).	Marked rotatory.....	
30	do.....	12	R. -0.75 D. L. -1 D. sphs.	Slight.....	
30	do.....	12	R. -1.25 D. L. -1 D. sphs.	Marked.....	Vertigo and photophobia.
48	do.....	30	R. +2 D. L. +2.5 D. sphs.	Slight.....	Photophobia.

^a Browne, F. J., and Mackenzie, J. R., Op. cit., pp. 838-839.^b 8 years on coal; 4 years a timberman.

Details of 100 cases of miners' nystagmus—Continued.

Age.	Occupation.	Time under-ground.	Refraction.	Oscillation.	Remarks.
67	Miner.....	Years. (a)	Simple myopia, well marked.	Marked	Complains of giddiness.
40	do.....	20	R. +0.75 D. sph. L. +0.50 D. sph.	Slight	
43	do.....	25	R. +0.75 D. vert. cyl. L. +0.50 D. vert. cyl.	Rotatory	Marked headache and vertigo.
39	do.....	10	R. +1.25 D. L. +0.50 D. sphs.	Marked	Photophobia.
33	do.....	20	Simple myopia, -3 D. in both eyes.	Rotatory	Do.
23	laborer.....	b 11	R. +4 D. vert. cyl. L. +4.50 D. vert. cyl.	Slight	Do.
43	Miner.....	25	R. +0.25 D. sph. L. +0.50 D. vert. cyl.	do.	Headaches and vertigo.
26	do.....	(c)	R. +0.50 D. sph. L. +0.50 D. sph.	Marked	No nystagmus when left coal cutting.
			-3 D. horiz. cyl. -1 D. horiz. cyl.		
24	do.....	11	R. -0.75 D. cyl. axis 120°. L. -0.5 D. sph.	do.	Marked quivering of eyelids.
38	do.....	25	R. +0.75 D. vert. cyl. L. +1 D. vert. cyl.	do.	Marked photophobia.
21	do.....	8	R. +1 D. cyl. axis 75°. L. +0.75 cyl. axis vert.	Slight	Vertigo occasionally.
42	Colliery examiner.	(d)	Slight hypermetropia in both eyes, +0.50 D.	Marked	Pain in eyeballs and vertigo.
45	Timberman.....	(e)	R. +0.75 D. horiz. cyl. L. +1.25 D. sph.	Not marked	Conjunctivitis and photophobia.
			-2.25 D. horiz. cyl.		
35	Miner.....	(f)	R. -1 D. horiz. cyl. L. -6 D. sph.	Slight	Quivering of eyelids and headache.
36	do.....	(g)	Oblique myopic astigmatism.	Marked	Frequent headaches.
20	do.....	5	Hypermetropic astigmatism +1 D. in both eyes.	Marked on stooping	Worked as timberman for past 10 months.
34	do.....	17	R. +2 D. horiz. cyl. L. +2.50 horiz. cyl.	Fine oscillation	Very marked when in stooping position.
35	do.....	(g)	Simple myopia. R. -3.5 D. L. -3 D.	Marked	Frequent attacks of giddiness.
34	do.....	20	Simple hypermetropia. R. +2 D. L. +4 D.	do.	Vertigo.
44	do.....	33	R. -1.50 D. sph. L. -2.50 D. sph.	Slight	Vertigo. (Has worn glasses for some time.)
18	do.....	2	R. -2.75 D. sph. L. -5.50 D. sph.	do.	
			-1.75 D. horiz. cyl. -3.50 D. horiz. cyl.		
41	do.....	29	Refraction normal.	Marked rotatory	
34	do.....	25	R. -2.50 cyl. L. +0.50 sph. C. -3 D. cyl.	Very marked	
27	do.....	13	R. Myopic astigmatism. L. Hypermetropic astigmatism (both of low degree).	Fine oscillation	Marked photophobia and vertigo.
22	do.....	10	R. +7 D. L. +6.50 D. sphs.	Rotatory	Photophobia and conjunctivitis.
29	do.....	17	No refraction error.	Marked	Worked last seven years with naked light.
45	do.....	38	R. +2.5 D. L. +2 D. sphs.	do.	
51	do.....	40	R. and L. +0.50 sphs.	do.	
18	do.....	5	Mixed astigmatism in both eyes.	do.	Vertigo.
52	do.....	30	R. and L. +2 D. sphs.	do.	Conjunctivitis and photophobia.
33	do.....	20	R. and L. +1.5 D. sphs.	Slight	Marked photophobia.
25	do.....	11	R. -6 D. sphs. L. -7 D. sphs.	do.	Marked photophobia and quivering eyelids.
40	Hauler.....	(h)	Unable to complete refraction examination owing to patient becoming sick.	Rotatory	Headache and vertigo frequent.
38	Miner.....	15	R. hypermetropic astigmatism vertical. L. hypermetropic oblique.	Slight	Vertigo marked.
33	do.....	22	Hypermetropic astigmatism in both eyes.	Rotatory	

47	do.	Hypermetropia in both eyes.	Marked on stooping.	Nictitation.
23	do.	Oblique hypermetropic astigmatism in both eyes.	Oblique.	Photophobia.
35	do.	R. -0.50 D. L. -1.50 D. sphs.	Slight.	Nictitation and photophobia.
24	do.	R. +0.50 D. with slight myopic astigmatism. L. refraction normal.	Rotatory.	Marked photophobia.
25	do.	+0.75 D. sphs. in both eyes.	Slight.	
38	do.	R. -1.5 D. L. -2 D. sphs.	Marked	
41	do.	-1.75 D. sphs. R. and L.	do.	Nictitation, vertigo, and conjunctivitis.
25	do.	Refraction normal.	Slight.	Severe headaches.
25	do.	R. -2 D. cyl. horiz. L. -2 D. cyl., axis 120°	do.	Marked nictitation.
24	do.	R. and L. +0.50 vert. cyls.	do.	Headache and vertigo.
53	do.	Myopic astigmatism in both eyes.	Marked	Retinoscopy almost impossible because of photophobia.
39	do.			Nictitation and photophobia.
18	do.	Normal.	Slight.	Photophobia.
21	do.	Simple hypermetropia in both eyes.	do.	Marked conjunctivitis.
32	do.	R. +1.5 D. sph. L. +1 D. obliq. cyl.	do.	Severe headaches with photophobia.
27	do.	Oblique hypermetropic astigmatism in both eyes.	Marked	Severe headaches.
34	Timberman.	Simple myopia in both eyes.	do.	Vertigo.
22	Miner.	Normal.	Slight.	Headache and photophobia.
38	do.	R. +1.5 D. sph. L. +1 D. sph. +1.5 D. cyl.	Marked	Conjunctivitis, marked.
41	do.	Simple hypermetropia in both eyes.	do.	
34	Driver.	R. and L. +0.50, oblique astigmatism.	Marked rotatory.	Headache and vertigo.
35	Miner.	Slight hypermetropic astigmatism.	Rotatory.	Marked vertigo and photophobia.
46	do.	+1.4 D. sphs. in both eyes.	do.	
49	do.	R. -1 D. cyl., axis 120°. L. -0.75 D. cyl., axis 60°	Slight.	Photophobia and nictitation.
21	do.	No error.	Fine oscillation.	
40	do.	R. -0.75 D. L. -1.25. Oblique cylinders.	Rotatory.	Photophobia.
50	do.	R. +6 D. L. +4 D., with slight oblique hypermetropic astigmatism in both eyes.	Marked	
28 ^a	do.	R. +1 D. horiz. cyl. L. +1 D. obliq. cyl.	do.	Marked twitching of eyelids.
12	do.	R. = Normal. L. -1 D.	do.	Photophobia.

^a Miner all his life.

^b Months.

^c 8 years on coal; 1 year laborer.

^d 15 years previously on coal.

^e 20 years on coal; 10 years timberman.

^f Worked in coal mine 20 years.

^g More than 20 years.

^h 1 twenty-five years on coal; 5 years hauler.

Other important results disclosed by the table can not be conveniently summarized in a statistical form.

METHODS OF PREVENTION.

The authors ^a sum up their conclusions regarding prevention in the statement that this resolves itself into medical examination of all men engaged to work underground, and the periodical examination of all underground workers for (a) the presence of refraction errors, (b) any signs of incipient nystagmus, and (c) physical or nervous debility. The authors emphasize the importance of adequate light, and they were surprised to find that even in the most up-to-date collieries there was, as yet, no indication of electric light being used throughout the workings. They were of the opinion that if such precautions were taken, and electric light installed in all working places in collieries, or if electric lamps capable of giving light for at least eight hours were supplied to all underground workers, miners' nystagmus would soon be unknown, and serious accidents to workmen, and consequent loss to the employer, would much more rarely occur. They overlooked the fact that electric light can not be used in gaseous mines for the essential purpose of determining the presence of fire damp.

METHODS OF TREATMENT.

The only curative treatment prescribed is rest, the use of strychnine, and the correction of refraction errors. However, the correction of refraction errors would require suitable glasses, which, of course, could not be worn underground. The conclusions are summed up briefly as follows: ^b

1. There are certain important contributory factors in the production of miners' nystagmus, such as inadequate light, refractive errors, and muscular strain.
2. Nystagmus is a menace to the miner working underground, as it may prevent the early detection of flaws in the roof, and falls may result. An illustration of the gravity of this danger is the fact that one of our cases was a colliery examiner.
3. We are convinced that the preventive and remedial measures suggested would, if carried out thoroughly, soon make miners' nystagmus a very rare complaint and greatly facilitate the detection of the small blue cap which indicates the presence of fire damp.

A PROBLEM IN WORKMEN'S COMPENSATION.

A more recent scientific study of miners' nystagmus is the lecture by Llewellyn,^c Tyndall research student of the Royal Society, delivered at the Mining Machinery Exhibition, London, on May 31, 1913. In this address certain aspects of the disease are treated from new standpoints, and throughout the fact is kept in mind that nystagmus, because of the workmen's compensation law, is of considerable eco-

^a Browne, F. J., and Mackenzie, J. R. *Op. cit.*, pp. 837, 840.

^b Browne, F. J., and Mackenzie, J. R., *Op. cit.*, p. 840.

^c Llewellyn, T. L., A lecture on miners' nystagmus: *Brit. Med. Jour.*, June 28, 1913, pp. 1359-1361.

conomic interest to mine owners and insurance companies. After restating the conclusions now rather generally accepted, that miners' nystagmus is an occupational disease of the nervous system and is found only among workers in coal mines, the author refers to the first case described, in Belgium in 1861, by De Conde, and then mentions the work of C. Bell Taylor, Nieden, Von Graefe, and Snell. Romiée is mentioned as having pointed out that the earliest recorded case was described in Belgium 10 years after the safety lamp had been recommended for use in that country and that it was only after the compulsory introduction of the Mueseler lamp in 1876 that an increase in the number of cases of the disease was noted. Llewellyn ^a summarizes the two principal views as regards the causation of the disease in the statement that (1) nystagmus is due to the position assumed by the miner at his work, and (2) that it is due to deficient illumination. The first view was ably and strongly advocated by Dransart, Nieden, and Snell, and the controversy of Snell with Court was referred to in the statement that Court was the first English observer to call attention to the importance of the light factor. The importance of the light factor is now accepted by practically all English observers, but on the Continent a diversity of opinion continues to prevail.

RELATIVE FREQUENCY OF SYMPTOMS.

The lecture of Llewellyn is of unusual value, in that it includes an analysis of 600 cases. The discussion regarding the frequency of the various symptoms, and the statistical data concerning 600 cases, follow: ^b

Symptoms.—The first symptom is failure of sight, especially at nighttime, or when the sufferer is called upon to perform the more skilled portion of his work. The man next complains that the lamps dazzle his eyes, and sooner or later that the lamps and all surrounding objects dance before him. Headache, varying from slight pain between the temples to attacks of extreme severity, giddiness on exertion and stooping, inability to see at nighttime, and dread of a bright light are often present.

There are two distinct varieties of the disease. In the first the symptoms are absent or latent, and the man, suffering no disability, is unaware that he has nystagmus; in the second the disease is manifest and the man is more or less incapacitated, and aware that his eyes are affected. Among 750 consecutive cases, 150 latent cases were observed.

The table shows the frequency of the various symptoms in the remaining 600 manifest cases.

Symptoms in 600 manifest cases.

Symptom.	Number of cases.	Percentage of 600 cases.	Symptom marked.	Symptom very marked.
Movements of objects.....	566	94.3		
Headache.....	507	84.5	51	16
Giddiness.....	490	81.6	52	8
Night blindness.....	459	76.5	4	
Dread of light.....	284	47.3	10	

^a Llewellyn, T. L., Op. cit., p. 1339.

^b Llewellyn, T. L., Op. cit., p. 1359.

The physical signs are briefly stated to be involuntary and irregular movements of the eyeballs, chiefly of a rotatory character, tremor of the eyelids, eyebrows, head, and, in some cases even of the neck and shoulders. There is also often a backward inclination of the head with drooping eyelids. Reference is made to a recent attempt to describe a condition in which miners' nystagmus could exist without the presence of nystagmus proper, or, in other words, where the oscillation of the eyeballs would be replaced by a blinking of the eyelids; this question has not been settled, but it was at the time under consideration by a departmental committee. The numerical frequency of the disease, which, according to foreign authors, runs from 5 to 20 per cent of all workmen underground, is shown in a table of the certified cases according to the workmen's compensation act for the years 1908-1911, as follows: ^a

Frequency of disablement.

Year.	Number of certified cases.	Proportion of cases to underground workers.
		<i>Per cent.</i>
1908.....	460	0.06
1909.....	1,011	.23
1910.....	1,618	.19
1911.....	2,519	.29

INCAPACITY FOR WORK CAUSED BY NYSTAGMUS.

The results of Llewellyn's inquiry regarding incapacity for work resulting from nystagmus are summarized in the following statement: ^a

Slight cases can soon return to work underground; ordinary cases can return after an interval of surface work of 3 to 12 months. Although one attack of nystagmus predisposes to another, I think it only fair to allow a man to try to regain his income by working underground again if possible. The exceptional cases should not return to work underground, and by exceptional cases I mean the following: Men who have failed to work several times before, very young lads, old men with commencing cataract, men with high degree of refractive error, and those cases which have been of exceptional severity. The following table was taken from returns, extending over four years, from five large colliery companies employing over 28,000 men:

Back at old work.....	152, or 45 per cent.
Left employ or commuted.....	9
At surface work.....	105
Idle.....	73

MINE DANGERS RESULTING FROM NYSTAGMUS.

In reply to the important question as to whether it is dangerous to employ a man on the ground that he has once suffered from nystagmus, Llewellyn ^a comments as follows:

In the first place, is the man more liable to accident? It is very difficult to answer this question. Men are often sent out of the pits by managers from fear of this danger,

^a Llewellyn, T. L., A lecture on miners' nystagmus: Brit. Med. Jour., June 28, 1913, pp. 1359-1361.

but this is when they are about to fail on account of the disease. I think it probable that many slight accidents are due to nystagmus, but I have only once had a complaint from a man that his accident was directly due to his nystagmus. There is, however, the possibility of a greater danger, namely, that a catastrophe may result from the failure of a fireman or collier suffering from the disease to detect the presence of gas. The table given below shows the results of tests made on all the firemen of five large collieries. The tests were made on the surface with the help of an Oldham gas-testing chamber. The men were first examined for the presence of nystagmus, and then tested independently for their ability to detect the cap given in the presence of gas.

The evidence to substantiate the foregoing conclusions is set forth in the table below:

Results of examination of miners for ability to see gas cap.

Condition of miner.	Number of men tested.	Number giving correct estimate.	Quantity of gas shown by cap.					
			Trace.	1 per cent.		2 per cent.		3 per cent.
			Failed.	Failed.	Underestimated.	Failed.	Underestimated.	
Normal.....	49	28	14	4	9		14	Seen by all, but frequently underestimated.
Nystagmic.....	41	4	19	10	13	6	12	

The table shows that all the men examined were able to detect the presence of gas when 3 per cent was in the chamber; but the nystagmic cases are shown to have been responsible for more mistakes than were made by men not afflicted with the disease.

DETAILS OF ENGLISH EXPERIENCE.

The statistical results of the analysis are, in brief, that the mean age was 39.84 years and the mean number of years of underground life was 25.58 years. These averages should be compared with the analysis of 100 cases by Browne and Mackenzie and of another 100 cases by Elworthy. The occupations of 685 cases were given, but underofficials were excluded. It was brought out that although all classes of workmen were affected, the great majority of the men were employed at the face of the mine. Out of 685 cases of all underground employees 557, or 81.3 per cent, were either miners or mine laborers employed as fillers or loaders. The number of timbermen and repairers suffering from nystagmus was 52, or 7.5 per cent, and the number of haulers or trackmen was 40, or 5.8 per cent. Other occupations represented were: Rippers, 8; laborers, 6; contractors, 5; underofficials, 3; and hitchers, engine drivers, hostlers, and masons, 1 each. This analysis does not show clearly what is meant by the previous statement, as given in the lecture, that underofficials were not considered.

As regards the method of getting coal and its relation to nystagmus, it is pointed out that although many authors hold undercutting with a pick to be the chief factor in the production of the disease, the following analysis is based on answers given by 580 nystagmus cases who either were or had been miners. Much holing, or undercutting, accounted for 177 cases and some holing for 171, or a combined total of 348 cases, or 60 per cent. In 40 cases the men had done little holing and in 192 cases no holing, or a combined total of 232 cases, or 40 per cent. In further explanation of this point it is stated ^a that:

Colliers in Somerset, Forest of Dean, and in the house coal pits of South Wales all get their coal by bottom-holing, yet nystagmus is very rare in these pits. The collier when holing is supposed to direct his eyes obliquely upward, and the advocates of the old school say that nystagmus results from the strain produced by this unnatural position of the eyes; but does a collier look obliquely upward when he holes? A collier looks upward when engaged in top-holing, but not when he holes in the bottom. The eyes are then either directed straight forward or a little downward. A little consideration will show that the swing of the pick will be more powerful and complete when the blow is ended below the level of the eyes.

RELATION OF NYSTAGMUS TO THICKNESS OF SEAMS WORKED.

The bearing of the thickness of the seams in which miners work on the relative frequency of nystagmus was inquired into, but the results of the investigation were seemingly negative. The results are summarized in the table below: ^b

Relation of thickness of seams to frequency of nystagmus.

Thickness of seam.	Number of cases of nystagmus.
Less than 2 feet.....	1
2 to 3 feet.....	47
3 to 4 feet.....	133
4 to 5 feet.....	148
5 to 6 feet.....	115
6 feet and over.....	141

On the important question of illumination it is stated ^b that:

In metalliferous mines candles or open lamps are used, while in a coal mine safety lamps are often necessary. The naked-light coal mine comes midway between the safety-lamp coal pit and the metalliferous mine, having the general blackness of the former and the good light of the latter. Manifest nystagmus is common in the safety-lamp coal pit, rare in the open-light coal pit, and unknown in the metalliferous mine. Nystagmus is practically unknown in the purely naked-light districts of Somerset and the Forest of Dean and is rare in the open-light pits of South Wales. In South Wales most of the men had worked at one time or another with lamps, and it is common for the men to continue working in an open-light pit after they have failed to work with lamps. Taking into consideration the number of men employed, England and Wales, using safety lamps three times more frequently than Scotland, had four times the number of cases of nystagmus in 1910.

^a Llewellyn, T. L., A lecture on miners' nystagmus: Brit. Med. Jour., June 28, 1913, p. 1360.
^b Llewellyn, T. L., Op. cit., p. 1359-1361.

SAFETY LAMPS AND INADEQUATE ILLUMINATION.

Of the number examined, 741 men had used safety lamps, and 723 of these had used such lamps almost exclusively. Only 9 of the men suffering from nystagmus had worked with candles alone. As the result of a special investigation in South Wales, the data summarized in the tables below were obtained.^a The facts are of special interest in that the number of men working in both classes of mines was known and the illumination at the coal face had been tested.

Number of cases of nystagmus and average mine illumination.

Working place.	Relative proportion of certified cases of nystagmus, to men employed.	Average illumination at coal face.
Safety-lamp pit.....	<i>Per cent.</i> 6.3	<i>Foot candles.</i> 0.008, or 1
Candle pit.....	1	.09, or 5

The conclusion is therefore advanced that in the same district the incidence of nystagmus was found to vary inversely with the candlepower of the lamps used. This important and far-reaching conclusion is sustained by the next table,^a which gives the number of cases of nystagmus, together with the number of men employed and the candlepower of the lamps:

Comparison of number of nystagmus cases and candlepower of lamps used.

Pit.	Number of men employed.	Number of cases of nystagmus.	Rate per 1,000 employed.	Candlepower of lamps.
A.....	450	9	20.0	0.235
B.....	1,400	22	15.7	.27
C.....	1,500	10	6.7	.33
D.....	2,500	14	5.6	.4
E.....	1,900	8	4.2	.42

I have included in this table a new column, showing the nystagmus rate per 1,000, to facilitate a more precise comparison of the different groups.

The relative efficiency of different types of lamps and their relation to nystagmus is discussed at some length in Weyl's treatise on industrial diseases,^b which includes a reference to the Pollak lamp, with illuminating power of 0.9 of normal candlepower. Weyl is of the opinion that the only hope for relief lies in the direction of a material improvement in the illuminating efficiency of the existing types of safety lamps.

^a Llewellyn, T. L., A lecture on miners' nystagmus: Brit. Med. Jour., June 28, 1913, pp. 1359-1361.

^b Weyl, T., Handbuch der Hygiene, Jena, 1897, pp. 284-285.

DIFFERENTIAL FACTORS OF ILLUMINATION.

Llewellyn continues his interesting discussion by a careful consideration of the differential factors of illumination at the coal face, which in the main consists (1) of the candlepower of the source of light used; (2) the distance at which this light has to be placed from the coal face; (3) the character of the surroundings, and (4) the composition of the air at the coal face. In some detail these points are discussed as follows:^a

- 1. The candlepower of the wax candles used in mines is generally equal to one standard candle, but the tallow candle may be equal to two. The oil safety-lamp rarely gives more than one-third of a candlepower at the coal face when clean and much less when dirty. Some dirty lamps have given only one-tenth of a candlepower.
- 2. The candle can be placed close to the coal face, but the lamp must be placed out of danger and is always much farther from the coal face. As the intensity of illumination varies inversely with the square of the distance, the advantage of the candle is very great.
- 3. In the coal mine practically all the incident light is absorbed and the advantage of reflected light is lost. We do not realize how much of the lighting of interiors is due to this reflected light, but the difference between a room papered with light paper and one with a dark red paper is very obvious.
- 4. The light of a safety lamp diminishes when the oxygen percentage of the air falls and the presence of moisture has the same effect. The presence of gas up to 4 per cent increases the luminosity of the flame. So accurately does the safety lamp answer to the various changes in the atmosphere that a rough estimate of the oxygen percentage might be calculated by taking photometric readings of a standard oil lamp first under normal conditions and then in the different districts of the mine.

The scientific thoroughness of the investigation is further emphasized by an analysis of the amount of light falling on the coal face in a number of mines. In five open-light mines the average illumination at the coal face was 0.09 foot candle, against an average illumination of only 0.018 in eight safety-lamp mines, or only about one-fifth of that in an open-light mine. The relation of the amount of holing done combined with different kinds of illumination on the prevalence of nystagmus is further shown in the form of a table, which fully sustains previous conclusions.^b

Bearing of amount of holing combined with different kinds of illumination on the prevalence of nystagmus.

District.	Amount of holing.	Position of miner at work.	Thickness of seam.	Character of illumination.	Prevalence of nystagmus.
Somerset.....	Much.....	On side.....	<i>Feet.</i> 1½ to 3½	Candles...	Unknown.
Forest of Dean.....	do.....	do.....	2' to 4'	do.....	Do.
Open-light pits, South Wales.....	do.....	On side or knees.	2½ to 5	do.....	Rare.
Safety-lamp pits, South Wales.....	None.....	On knees or standing.	3½ to 6	S a f e t y lamps.	Common.
Midlands.....	Much.....	On side.....	5 to 7	Lamps....	Do.

^a Llewellyn, T. L., A lecture on miners' nystagmus: Brit. Med. Jour., June 28, 1913, pp. 1359-1361.
^b Llewellyn, T. L., Op. cit., p. 1361.

VISUAL DEFECTS AND EYE ACCIDENTS.

Aside from the mechanical factors influencing the rarity or frequency of nystagmus, the personal factor requires to be taken into account. Llewellyn^a points out that the importance of the personal factor is now recognized by a large number of surgeons and that ocular defects play an important part in determining whether a man should have nystagmus. He sums up his own investigations in the statement that, aside from 225 negative cases which either were not examined or were obviously in too bad a condition to admit of a test, there were only 95 cases of normal vision. The number of men with serious errors of refraction was 430, or 81.9 per cent of the cases examined. The kinds of visual impairment were as follows: Hypermetropia, 170; myopia, 57; and astigmatism, 203. It is properly pointed out that a small error of refraction is common in normal persons, and furthermore that accidents and ill health are also determining factors. These observations, however, do not detract from the profoundly significant statement that, underlying the mechanical problem of defective illumination is the equally important question of fundamental errors of refraction, for which there is only one remedial agency known, and that is suitable glasses, which can not very well be worn underground. Accidents and ill health, however, are of sufficient importance to require some consideration, and according to the present investigation in 146 cases there was a previous history of an accident, in 73 cases to the eye, in 43 cases to the head, and in 30 cases the injuries were general. In North Staffordshire, it is further stated, accidents to the eye occur frequently before the onset of nystagmus. In the first 600 cases examined there was a history of accidents to the eyes in 36 cases, and in the last 150 cases, all from North Staffordshire, there had been injuries to the eyes in 37 cases, or 24.7 per cent. The final observations by Lewellyn^b have reference to preventive treatment, and are briefly summarized as follows:

It is in the first place necessary to improve the miners' lamp, and the mining engineer must no longer be content with an average illumination of one-fiftieth of a foot candle at the coal face. The introduction of electric lamps into general use is probable, as it seems unlikely sufficient light can be obtained in any other way. The elimination of unfit workmen by medical examination before employment would also be of the greatest service. Efficient ventilation and any hygienic measures will also help.

ESTIMATE OF NYSTAGMUS IN THE UNITED STATES.

The statistical application of the foregoing considerations to the coal-mining industry of the United States is rather limited at present. No trustworthy data exist which warrant more than an ap-

^b Llewellyn, T. L., A lecture on miners' nystagmus: Brit. Med. Jour., June 28, 1913, p. 1361.

^a Llewellyn, T. L., Op. cit., pp. 1359-1361.

proximate estimate of the probable number of nystagmus cases among American coal miners. According to the statistics of the Bureau of Mines the number of men employed underground is estimated at 596,470 for the year 1913.^a As the average rate of new cases of nystagmus reported under the British workmen's compensation act during the five years ended with 1912 had been 9.2 per 10,000 employed, this rate, when applied to the total number of persons employed in coal mining in the United States in the year 1913, given by the Bureau of Mines as 747,644,^b would indicate the possible, if not probable, existence of 688 new cases of nystagmus per annum. As the cumulative rate of old and new cases under the English experience by the year 1912 had reached 29.8 per 10,000, this would indicate a possible, if not the probable, number of persons employed in American coal mining and affected with nystagmus as numbering 2,228 for the year 1913. These rates are unquestionably conservative, for they are far from the 5 per cent of ascertained cases for certain mining districts of Germany. If the proportion of American coal-mine employees affected with nystagmus were as high as 5 per cent, the number of such cases estimated for the year 1913 would be 37,382.

NYSTAGMUS STATISTICS OF THE UNITED KINGDOM.

The table following exhibits the cases of nystagmus among miners in the United Kingdom who received compensation under the workmen's compensation act during the five years ended with 1912. The number of coal miners has been derived from the annual reports of the chief inspector of mines and quarries, and the number of new cases, and new and old cases combined, from the annual statistics of the operations of the workmen's compensation act.

Cases of miners' nystagmus compensated for under the workmen's compensation act, United Kingdom, 1908-1912.^c

Year.	Number of coal miners.	Data on nystagmus.			
		Number of new cases.	Rate per 10,000 coal miners.	Number of old and new cases.	Rate per 10,000 coal miners.
1908.....	972,232	386	4.0	460	4.7
1909.....	997,708	631	6.3	1,011	10.1
1910.....	1,032,702	956	9.3	1,618	15.7
1911.....	1,049,897	1,374	13.1	2,518	24.0
1912.....	1,072,393	1,376	12.8	3,195	29.8
Total.....	5,124,932	4,723	9.2		

^a Fay, A. H., Monthly statement of coal-mine fatalities in the United States, October, 1914, with revised figures for preceding months: Bureau of Mines, 1915, p. 21.

^b Fay, A. H., Loc. cit.

^c From the annual reports of the chief inspector of mines and quarries.

The table emphasizes the importance of miners' nystagmus as an occupational disease. This aspect of the problem is briefly reemphasized in the following introductory remarks to an extended address on miners' nystagmus in a course of lectures delivered before the Royal College of Physicians of London by Shufflebotham: ^a

Miners' nystagmus must be regarded as the commonest of all occupational diseases. This may be due to the fact that the mining industry is, after agriculture, the largest industry in the country. In my opinion the number of cases of miners' nystagmus far exceeds the numbers which would be given in compensation statistics, which take account only of cases in which undoubted incapacity for work has been produced, and not of the much larger numbers of early cases in which the patients are able to continue in their employment.

NYSTAGMUS AS AN INDUSTRIAL DISEASE.

The subject of nystagmus is referred to for the first time at some length in the home office report on the statistics of compensation for the year 1912.^b An extract follows:

The figures for nystagmus are remarkable. In the first full year (1908) during which the new provisions as to industrial diseases were in operation, the number of nystagmus cases was 460 (of which 386 were new cases and 74 continued from the last half of 1907); 380 of these cases were continued into 1909, and 631 new cases arose, or 1,011 cases in which compensation was paid in 1909; 662 of these were continued into 1910, and 956 new cases arose, making a total of 1,618 cases in 1910; 1,144 were continued into 1911, and 1,375 new cases arose, making a total of 2,519 in 1911; 1,819 cases were continued into 1912, and 1,376 new cases arose, making a total of 3,195 in 1912. In 1908 the remedy was still probably unfamiliar, but a comparison of 1912 with 1909 shows that the number of new cases arising annually has more than doubled. The 1912 figures, however, show that the growth in the number of new cases has stopped for the present. What is perhaps more important is that the figures of "continued cases" show that the proportion of long-continued disablement cases is very high; the number of cases continued from 1911 to 1912 greatly exceeds the number of new cases that arose in 1911. It is evident that the adoption of means to prevent the occurrence of this disease, which the most recent investigations attribute to insufficiency of the light by which miners do their work, is becoming a matter of importance to the employer.

The report states that during 1913 there was a further increase in the number of new cases of nystagmus, the statement in the report^c being as follows:

As regards nystagmus, attention was drawn, in the corresponding section of the introduction to the statistics for 1912, to the remarkable increase which has occurred each year since 1908 in the total number of cases of this disease in which compensation has been paid, but it was noted that in 1912 the growth in the number of new cases had, for the time being, stopped. The figures for 1913, however, show again a striking increase both in cases continuing from the previous year and in new cases.

^a Shufflebotham, Frank, The hygienic aspects of the coal-mining industry in the United Kingdom: Brit. Med. Jour., Mar. 21, 1914, p. 648.

^b Statistics of compensation and of proceedings under workmen's compensation act, 1906, and the employers' liability act, 1880, during year 1912, London, 1913, p. 9.

^c Loc. cit.

ESTIMATE OF COMPENSATION COST.

It is regrettable that the statistics for nystagmus should not be given in sufficient detail as regards the total and average amounts paid in compensation and the average duration of the illness. As the large majority of cases of compensation on account of industrial diseases in the mining industry of Great Britain were for nystagmus, it would seem reasonably safe to apply the figure thus obtained to the cases compensated for during the year 1912. The average amount paid in compensation on account of nonfatal cases of industrial disease in the mining industry was £14.43 (\$70.22). If this amount is applied to the 3,195 cases compensated during the year, the approximate total cost of workmen's compensation on account of nystagmus in the United Kingdom for the year 1912 was \$224,353. If the same amount were applied to the estimated number of nystagmus cases in the United States (2,228), the corresponding amount for the year 1913 would be \$156,450.

CONCLUSIONS OF COMMITTEE ON INDUSTRIAL DISEASES.

A full discussion of the compensation paid to workmen for nystagmus is contained in the first report of the Departmental Committee on Compensation for Industrial Diseases.^a In that investigation it was emphasized that the burden of proof should rest on the employer, that the disease was caused by insufficient light and also by the strained position of the head and eyes, that the diagnosis was fairly easy but that the first stage of the disease might easily be ignored, that complete incapacitation from the disease was rare, so that malingering was both possible and seemingly not uncommon. It was furthermore brought out that the proclivity to the disease was incurable, that the proportion of colliers affected was held by different witnesses to be rather variable. A rest or change of occupation was considered necessary for a cure, the burden of responsibility being placed upon safety lamps producing inadequate illumination. Upon the basis of the data procured the committee recommended that miners' nystagmus be added to the schedule. As their observations on the subject are of historical and practical interest they are given in full as follows:^b

Nystagmus.—This disease is prevalent among miners in certain districts, especially where the coal seams are thin. It is due primarily to fatigue of the elevator muscles of the eyes from the constrained position, in an oblique upward direction, in which the eyes have to be kept. Insufficiency of light from the lamp would appear to be a secondary but not inconsiderable cause. The miner mainly affected is the hewer who works at the coal face, but deputies in low seams, the on-setter in charge of the cage, and others also, may, and do, suffer. The objective symptom is an oscillation of the eyes (nystagmus), the rate varying from 100 to 300 times per minute, and asso-

^a Report of the Departmental Committee on Compensation for Industrial Diseases, London, 1907, pp. 21-22, 159-161, 402-403.

^b Op. cit., pp. 9-10.

ciated with it subjectively are headache, giddiness, and dancing of objects before the eyes, which cause frequently much discomfort and occasionally incapacitate the miner entirely from work. The malady, as a rule, does not occur under 30 years of age, and rarely until after 10 years from commencement of work. Recovery may be expected on cessation from pit work in 3 to 12 months' time, but long before this, in a few weeks, in the majority of cases, work not involving the particular eye strain is possible. Cases of nystagmus, as regards degree of incapacity, were classed for us by Dr. Meighan, surgeon to the Glasgow eye infirmary, in three groups: (1) those in which the patients are slightly affected and do not cease work; (2) those in which the oscillation is accompanied by giddiness, and where the men have to leave off their particular work underground; and (3) those where the men are obliged to cease work altogether. He considered that 5 per cent of men employed in mines would represent the number who sought treatment under one or other of the three classes, but that the first class would embrace most of the cases. The weight of evidence, however, was strongly in favor of the view that no matter what stage nystagmus might have reached when medical advice for symptoms due to it was sought, pit work should be entirely relinquished on the ground that this course alone would prevent aggravation. This view was expressed notwithstanding the fact that miners who had undergone treatment for nystagmus five or six years previously and been cured, were known to have resumed their ordinary work again and continued in it without, so far as the witnesses knew, further injury. The data on which this medical practice is based do not appear to us, from the evidence, to be entirely conclusive, and in some cases, perhaps, the advice appears to have been given as the result of dogmatic statements made on the subject rather than of actual experience. The importance and far-reaching character of this medical conclusion will at once be apparent, when it is remembered that the most prominent point brought out by the evidence in regard to the disease was that, although its existence can be easily diagnosed, the symptoms are largely subjective, and there is no necessary relation between the severity of the disease and the degree of incapacity. In other words, one man may exhibit a very marked oscillation of the eyes, and yet suffer little discomfort, and be able and willing to continue at his work; another may show overt symptoms less acute, and yet may claim, and claim truly, that he is incapacitated from his usual employment. This fact may perhaps give rise to difficulty in settling disputed cases of compensation. But since the only prospect of curing nystagmus is for the sufferer to abandon, if not altogether, at least for a time, employment below ground in badly lighted mines, it is clear that nystagmus may furnish a legitimate ground for compensation, even if the overt symptoms are comparatively slight. For the patient, though he may not at the time be actually unable to continue his work, ought to discontinue it if he is not to get worse; and if the result is that, under medical advice, he has to accept employment above ground at a lower wage, he is, in the words of the act, "disabled * * * from earning full wages at the work at which he was employed."

MALINGERING.

The question of malingering, on the alleged ground of incapacity from nystagmus, is one of considerable importance. As observed by Oliver:^a

The symptoms are entirely subjective, and there is no necessary relation between the severity of the oscillation and the degree of incapacity for work. Miners' nystagmus has been scheduled for compensation, but the fact just alluded to is sure to raise difficulties in settling disputed cases of compensation, since one coal miner may suffer little, although the subject of marked oscillation of the eyes, while another with less prominent signs may experience so great discomfort as truly to unfit him for work.

^a Oliver, Thomas, *Diseases of occupation*, London, 1907, p. 274.

A review of the literature on malingering fails to sustain the conclusion that the tendency to obtain compensation by fraud on account of impairment due to nystagmus is at all common. The most recent work, by Collie,^a mentions only two cases, which are not applicable to the present discussion.

There are also no references thereto in the treatise by Harbaugh.^b

CLONIC SPASM OF THE EYELIDS.

There is a reasonable chance of confusing clonic spasm of the eyelids with nystagmus, a matter that was rather fully considered in a special report of the Departmental Committee on Compensation for Industrial Diseases.^c It is observed in this report that—

The necessity for some investigation concerning clonic spasm of the eyelids (that is, spasmodic contraction and relaxation of the muscles of the eyelids) was indicated by suggestions that miners suffering from such spasm had been refused certificates of compensation because they did not exhibit the symptom nystagmus (that is, oscillation of the eyeballs), though the disease nystagmus was already scheduled by the Secretary of State's order of the 22d of May, 1907. The inquiries subsequently made by you of ophthalmic specialists and others had revealed considerable divergencies of experience and opinion as to the existence and nature of such a spasm, particularly to a disabling extent, apart from nystagmus; some authorities suggested that it was a variety of nystagmus, others that it was at any rate a symptom of that disease, and others that it was merely a habit. The questions involved were therefore referred to this committee.

The subject of clonic spasms of the eyelids is briefly referred to by Shufflebotham,^d as follows:

Clonic spasm of the eyelids is a common and in some cases the most prominent objective symptom. Sometimes it is an early, sometimes a late symptom, and very often it may remain after the oscillation of the eyeball has ceased. Llewellyn has pointed out that the movements of the eyelid associated with nystagmus are of two kinds, the coarse blinking movement and the fine tremor or clonic spasm, and in the former, although the movements may be quick, they are tonic and not clonic in nature. The rapidity of the clonic movements may exceed 100 a minute, and in some cases the movements may be so quick that it is impossible to count them. These movements may be exaggerated and made more obvious by adopting the same means as in oscillation of the eyeballs.

After considering all the evidence available the committee^e came to conclusions as follows:

We find that the word "nystagmus" is no more than the name of a symptom, and can not conveniently be employed to name a disease. It denotes only oscillation of the eyeballs. "Miners' nystagmus," on the other hand, is a term well understood to name a disease or group of symptoms, practically confined to miners, of which oscillation of the eyeballs (that is, "nystagmus") is the commonest, but not invariably pres-

^a Collie, John, *Medico-legal examinations and the workmen's compensation act, 1906*, London, 1912, 128 pp.

^b Harbaugh, C. H., *Causes of disability*, 1909, 650 pp.

^c Report of the Departmental Committee on Compensation for Industrial Diseases, London, 1913, p. A2.

^d Shufflebotham, Frank, *Miners' nystagmus*: *Brit. Med. Jour.*, Mar. 21, 1914, p. 650.

^e Report of the Departmental Committee on Compensation for Industrial Diseases, London, 1913, p. A3.

ent, objective sign. This disease has many symptoms, some subjective and some objective. We have no doubt that during its course, at some time or other, the symptom nystagmus appears in all cases. That is the conclusion we have come to on the evidence of those who have had the greatest experience, but we can not deny that, among those we heard, much diversity of opinion was expressed as to whether it is present at all times, or even susceptible of elicitation by repeated tests under conditions favorable to its perception. And, in some cases, accompanying it, or in others even replacing it in the later stages, may be clonic spasm of the muscles of the eyelids. Consequently the symptom nystagmus, however easily found in a great majority of cases, ought not in all to be taken as a conclusive test either of the presence or of the absence of a disease of which, after all, it is but one symptom. We find further that the suggestion that it has been taken as such a test is not altogether unfounded. We are satisfied that cases of miners' nystagmus may have been wrongly diagnosed, and that certificates of disablement are likely to be refused, through too much insistence on this one test; and we are convinced that it is necessary to make it abundantly clear to all those concerned in the administration of the act or in the diagnosis of cases that the condition, the existence or nonexistence of which to an incapacitating extent is to determine the question whether there can be a claim to compensation, is not the symptom nystagmus alone but the whole disease known as "miners' nystagmus." We also find that it is not sufficient and for various reasons would not be proper merely to call attention also to the additional symptom clonic spasm; all the symptoms, whether subjective (for example, movements of objects, headache, giddiness, night blindness, and dread of light) or objective (for example, movements of the eyeballs, tremor of the eyelids, eyebrows, head, and even of the neck and shoulders) must be taken into account. The question for decision is: "Do the symptoms present in this individual, the objective symptoms and the subjective symptoms taken together, with or without the history of the case and the other available evidence, show that he has miners' nystagmus to such an extent that he is wholly or partially incapacitated within the terms of the act."

As regards the point raised in *McGinn v. Udston*, we find that the word "nystagmus," being only the name of a symptom, either names no disease at all and so gives no title to compensation, or (and this is the interpretation on which the court acted) includes nystagmus even when it is a symptom of forms of disease (for example, Friedreich's ataxia, disseminated sclerosis, and tumor of the cerebellum) that are not industrial.

In view of the evidence given to us and the facts disclosed by recent researches as to the causation of miners' nystagmus by inadequate illumination at the coal face and elsewhere in the mine, we entertain the gravest doubt whether true miners' nystagmus can ever occur in persons other than miners. The committee of 1907, however, seem to have had such cases in mind (for though in the body of their report they referred to "miners' nystagmus," in their recommendation they spoke only of "nystagmus"). We are therefore of opinion that any amendment of the existing schedule should be so framed as to preserve the existing claim to compensation for cases of miners' nystagmus in persons other than miners, if such cases occur.

The "minutes of evidence"^a are of unusual value, including observations on the predisposition to miners' nystagmus, causation, and its occurrence in nonminers as well as its practical limitation to persons employed in the coal-mining industry. The symptoms are fully discussed, and the evidence collected on some points is rather technical. Clonic spasms of the eyelids by some witnesses was not considered a separate disease. Its connection with conditions other

^a Report of the Departmental Committee on Compensation for Industrial Diseases, London, 1913, pp. 82-87.

than miners' nystagmus, and its differentiation from other forms of blinking, were fully brought out. The subject of incapacitation by miners' nystagmus was considered, as was the subject of symptoms, as well as the chances of simulation or malingering and the risk of recurrence.

CONCLUSIONS.

In view of the foregoing, it would seem extremely improbable that an occupational affliction so well defined should be wholly absent in the coal-mining industry of the United States. General investigations are not likely to yield useful results, but specialized inquiries should be directed exclusively to underground employees in mines using exclusively or extensively safety lamps as a precaution against mine explosions. Even though some of the apparent increase in the frequency rates of nystagmus for the United Kingdom be attributed to malingering because of the compensation paid on account of incapacity for work, it would seem reasonable to suppose that more cases of malingering or fraud would have been reported than are shown by the available records. The economic importance of nystagmus as shown by German data is set forth in a summary statement, derived from the statistical reports of the Bochum Miners' Union,^a exhibiting the proportion of compensated nystagmus cases in the invalidity cases due to all causes, by divisional periods of life.

Invalidity cases on account of nystagmus in the Bochum Miners' Union, 1908-1912.

Age groups of miners.	All invalidity cases.	Nystagmus cases.	Invalidity due to nystagmus.
<i>Years.</i>			<i>Per cent.</i>
Up to 20.....	330		
21-25.....	790	49	6.2
26-30.....	1,713	280	16.3
31-35.....	2,691	718	26.7
36-40.....	2,660	784	29.5
41-45.....	2,324	705	30.3
46-50.....	2,766	539	19.5
51-55.....	2,866	269	9.4
56-60.....	1,836	76	4.1
61-65.....	724	11	1.5
66-70.....	164	2	1.2
Over 70.....	39		
Total.....	18,903	3,433	18.2

It is shown by this table that of all the invalidity cases on account of which compensation was paid, 18.2 per cent were the result of nystagmus. The actual number of such cases was highest at the ages of 36 to 40, and the relative proportion was highest at the ages of 41 to 45. It has not been feasible to reduce these cases to the basis of a

^a Allgemeiner Knappschafts Verein zu Bochum.

rate per 1,000 employed, by divisional periods of life, but the above table is entirely conclusive evidence that nystagmus is largely an affection of coal miners at the age of 31 to 50 years, when 19.5 to 30.3 per cent of all invalidity requiring compensation is due to this single and well-defined specific cause of disablement.

The relative frequency of the disease in the Bochum mining district is a matter of considerable practical importance. It may be questioned whether the subject has anywhere else received such extended and strictly scientific consideration. The activities of the Bochum Miners' Union are confined chiefly to the administration of the sick fund and of the invalidity insurance fund. The number of cases of nystagmus to which the sick fund was applied during the period 1905-1913 are shown in the following table: ^a

Number of cases of miners' nystagmus to which sick fund of Bochum Miners' Union was applied, 1905-1913.

Year.	Members in union.	Cases of miners' nystagmus.	Nystagmus cases per 1,000 members.
1905.....	269,000	970	3.61
1906.....	286,000	903	3.16
1907.....	309,000	1,098	3.55
1908.....	343,000	818	2.38
1909.....	348,000	1,333	3.83
1910.....	351,000	1,225	3.49
1911.....	357,000	1,371	3.84
1912.....	376,000	1,510	4.02
1913.....	409,000	742	1.81
1905-1909.....	1,555,000	5,122	3.29
1910-1913.....	1,493,000	4,848	3.25

These figures show that during the last four years covered by the table the average nystagmus rate has been practically the same as during the first five years covered; but that although the rate during 1912 was the highest on record, or 4.02 cases per 1,000 members exposed to risk, the rate for 1913 was only 1.81, or the lowest on record during the nine years under observation. The actual number of cases during 1913 was almost exactly one-half of the number requiring the application of the sick fund during 1912. However, the medical report of the Bochum Miners' Union for 1913 ^b explains that the reduction is not to be explained on account of a diminished frequency, but in conformity with a decision of the superior court that only the most serious cases of nystagmus were to be considered entitled to compensation in the future.

^a Verwaltungs-Berichte, Allgemeiner Knappschafts Verein zu Bochum, 1905-1913, Bochum, Germany, 1905-1913.

^b Vol. 1, p. 146.

Much the same result is obtained by an analysis of the invalidity cases to which the fund was applied during the same period, as shown by the following table: ^a

Number of cases of miners' nystagmus to which invalidity insurance fund of Bochum Miners' Union was applied, 1905-1913.

Year.	Members in union.	Cases of miners' nystagmus.	Nystagmus cases per 1,000 members.	Cases with secondary complications.	
				Number.	Per cent of nystagmus cases.
1905.....	263,000	463	1.76	107	23.1
1906.....	280,000	590	2.11	126	21.3
1907.....	301,000	432	1.43	72	16.7
1908.....	332,000	406	1.22	43	10.6
1909.....	340,000	757	2.23	61	8.1
1910.....	341,000	824	2.42	105	12.7
1911.....	348,000	797	2.29	73	9.2
1912.....	367,000	649	1.77	78	12.0
1913.....	396,000	195	.49	30	15.4
1905-1909.....	1,516,000	2,648	1.75	409	15.4
1910-1913.....	1,452,000	2,465	1.70	286	11.6

According to this table the invalidity rate on account of miners' nystagmus was 1.75 per 1,000 during the first 5 years and 1.70 per 1,000 during the last 4 years covered by the table. The reduction in the number of cases during 1913 is even more marked as regards invalidity cases than as regards sickness cases. The table includes a column showing the cases of nystagmus with secondary complications, and the proportion of such cases to the total number of miners entitled to invalidity annuities on account of temporary or permanent wage-earning incapacity as a result of nystagmus. The percentages show a wide range, from a minimum of 8.1 in 1909 to 23.1 in 1905. The percentages, of course, would be affected by special causes such as, for illustration, bronchial catarrh, pneumonia, and other respiratory diseases influenced by season. Out of a total of 5,113 cases of miners' nystagmus during 1905-1913, 695, or 13.6 per cent, were complicated by other causes or diseases, as follows: Other eye diseases, 262, or 5.1 per cent of the total number of nystagmus cases; other diseases of conjunctive tissue membrane and eyelids, 68, or 1.3 per cent; pulmonary emphysema and asthma, 104, or 2 per cent; acute and chronic articular rheumatism, 81, or 1.6 per cent; muscular rheumatism, 68, or 1.3 per cent; other causes or diseases, 367, or 7.2 per cent. To the pathologist, the significant fact brought out by these statistics is the large number of cases complicated by other diseases of the eyeball or of the conjunctive tissue membrane and the eyelids.

^a Verwaltungs-Berichte, Allgemeiner Knappschafts Verein zu Bochum, 1905-1913, Bochum, Germany, 1905-1913.

These additional observations further emphasize the practical importance of miners' nystagmus as an occupational disease. The modern tendency of including occupational diseases within the scope of workmen's compensation for accidents or injuries suggests the practical importance of a more extended consideration of the subject. As shown by the accompanying bibliography, there have been few useful and conclusive American contributions to the literature on nystagmus. Aside from the brief consideration of nystagmus in Thompson's treatise on occupational diseases, a still more limited consideration by Lloyd may be mentioned chiefly on account of two interesting illustrations of the constrained positions under which miners' nystagmus is, according to some authorities, most likely to occur. Such mining practices, however, are comparatively rare in the United States on account of the relative infrequency of narrow coal seams and the more extended use of coal-mining machinery. No reasons suggest themselves, however, why this peculiar affliction should be limited to mining districts of European countries and not be found in American coal-mining districts where, on account of the gaseous nature of the mines, the use of safety lamps is compulsory.

As shown by the European experience, the affliction is not likely to attract general attention until compensation is required to be paid for it. Llewellyn's estimate of compensation cost on account of miners' nystagmus in the United Kingdom, placed by him at nearly half a million dollars a year, is probably too high. However, if this country under liberal workmen's compensation laws should include compensation for industrial diseases, the problem of miners' nystagmus, aside from its humane considerations, will probably become much more important than it seems at present.

The information here presented should, however, serve the purpose of attracting general medical attention to an obscure affliction which, under existing conditions, may be erroneously diagnosed and neglected, when remedial measures would be of decided advantage to the miner and the mining industry.

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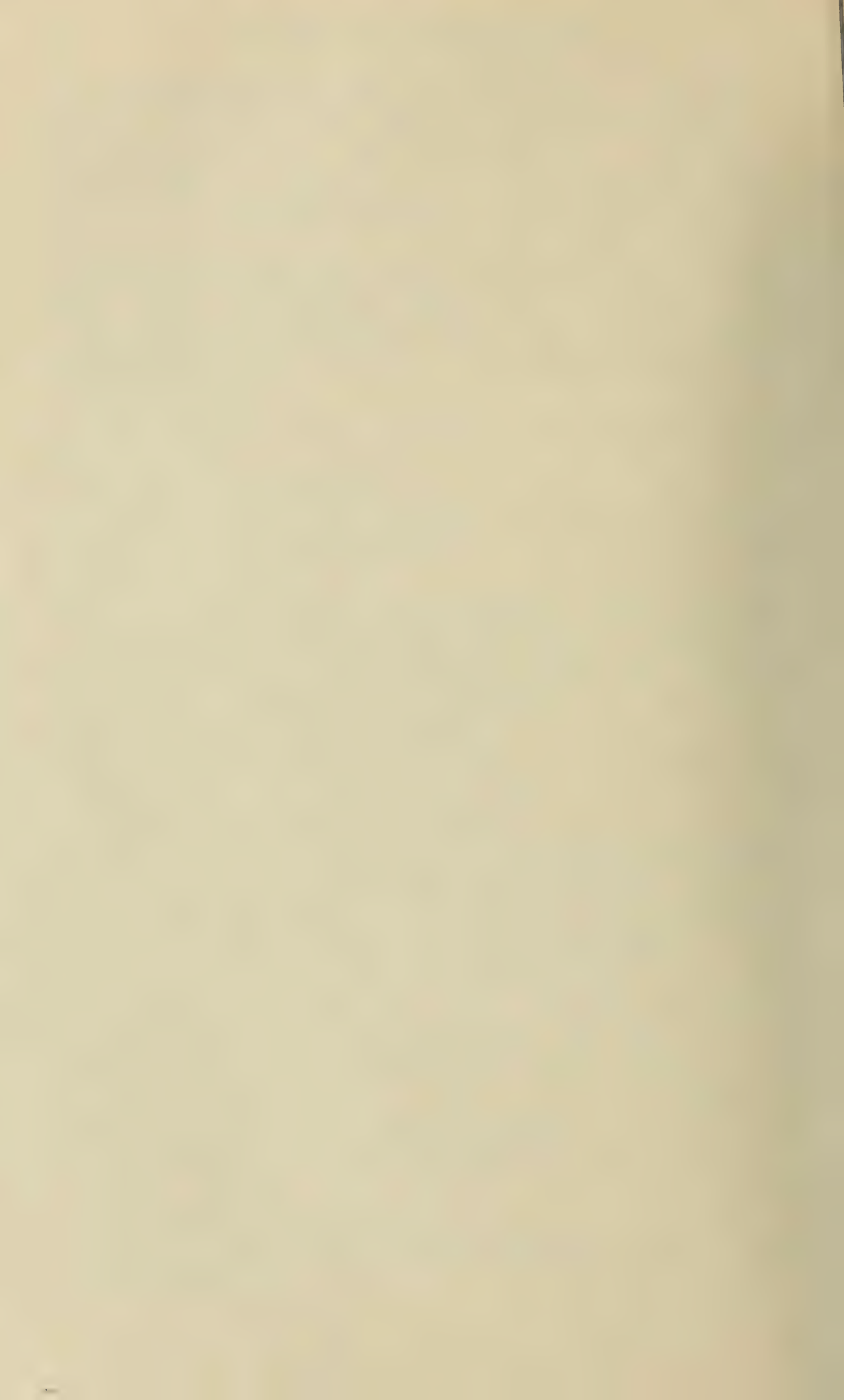
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